AGNIHOTRA

OR

AN ANCIENT PROCESS OF FUMIGATION

[A STUDY FROM THE CHEMICAL STANDPOINT]

By

SATYA PRAKASH, D.Sc.

Lecturer in Chemistry, University of Allahabad

THE SARVADESHIK ARYA PRATINIDHI SABHA

DELHI

1937

Price Rs. 2/8 or 5 shillings

Printed by M. N. Pandey at the Allahabad Law Journal Press, Allahaba
Published by The Secretary, The Sarvadeshika Arya Pratinidhi Sabha, De

TO
MY FATHER
PT. GANGĀ PRASĀD UPĀDHYĀYA

Allahaba
bha, De

It is a pleasure to look at a book written by a fullfledged scientist dealing with,—and what is still more significant, vindicating—the performance of Yajñas, *Sacrifices. The writer is a* Doctor of Science *and that too of the Allahabad University. He has brought to bear upon the subject all the scientific lore that he has acquired at the University and its eclectic environments. The performance of our much-maligned* Yajñas *has been sought here to be vindicated, mainly on the ground of their beneficial effects on the physical plane. An old Pandit may be pardoned for pleading a slight disappointment at the* spiritual *benefits being ignored. But he has to be thankful for small mercies and should feel satisfied with the fact that the sacrifices in question have been demonstrated—and scientifically demonstrated—to have far-reaching beneficial effects. It is hoped that the realisation of this truth will lead on to the belief that the beneficial effects thus demonstrated must have their reaction on spheres other than the purely physical.*

May the writer live long to continue his studies leading us to the realization of this truth, is the fervent hope of

Allahabad, *Ganganatha Jha*
April 28, 1937

FOREWORD

Different methods of fumigation have been practised in India from time immemorial along with religious performances and worship. Many of the processes have been described in the *Vedas*.

Dr. Satya Prakash, who is well versed in Chemistry and Sanskrit, has for the first time attempted to study the subject from a scientific viewpoint.

From researches carried on in this laboratory, it has been concluded that formaldehyde is produced in the oxidation of organic substances in air. It appears that in the process of fumigation as practised by burning all kinds of energy materials, formaldehyde and other antiseptic substances are likely to be formed. Moreover, by having a fire, the ventilation of the place where fumigation is taking place, improves.

It is believed that the fragrance of burning gummy materials and fibres is conducive to the concentration of the human mind for worship and meditation and this practice is in vogue in many

countries. Fire is considered in many religions as an emblem of purity and is believed to improve the mind.

These are common sense viewpoints regarding the effects of fumigation. In this book, Dr. Satya Prakash has described in detail various processes of fumigation and the composition of the energy materials utilised. In the last three chapters, the author has dealt in a very able manner the chemical changes involved in the oxidation of different substances.

As the book deals with the ancient practice in a systematic manner, I believe, it will be found interesting and useful to readers in the East and in the West, and hence, I have a great pleasure in commending it to the public.

April 22, 1937 N. R. DHAR

OM

PREFACE

Some three years back, Mahātmā Nārāyaṇa Swāmī, the President of the International Aryan League asked me whether I could undertake to write down something on the chemical side of Agnihotra, an ancient process of fumigation. The performance of Agnihotra has also been one of the sacred daily duties in my family, and since I entered into the chemical profession, I was also anxious to know whether any useful chemical interpretation can be attached to a process like this. I was aware of my difficulties, and even now while presenting a monograph on the subject, I am not sure whether all that could be done has been done.

In the first introductory chapter, the oriental side of the process has been given without which it was difficult to proceed on with the chemistry of the subject. Though non-chemical in nature, my chemist colleagues will find it interesting. The subsequent chapters deal with the analyses of the fumigating substances, the products of combustion,

and the germicidal, antiseptic and vermifugal properties of the products resulting in the course of fumigation.

For the analyses of different substances given in this monograph, the author has derived help from the following well-known books :

1. Pharmacographica Indica, by W. Dymock, C. G. H. Warden, and David Hooper, 1890-93, Vols. 1-3.

2. Indian Medicinal Plants, Vols. 1 and 2, by Kirtikar and Basu.

3. Indigenous Drugs of India, by R. N. Chopra, 1933.

4. The Volatile Oils, Vol. 1, by E. Gildemeister (English translation by E. Kremers), 1913.

5. Foods: Their Composition and Analyses, by A. W. Blyth and M. W. Blyth, 1909.

6. Fuel, by J. S. S. Brame, 1919.

7. Fuel Production and Utilisation, by H. S. Taylor, 1920.

8. Plant Products, by S. H. Collins and G. Redington, 1926.

Dymock's collection, though unique in its nature has now gone out of date. The author has made an extensive use of this book and has also supplemented it, wherever available, with the

recent literature.

For the third chapter, the author has taken help from valuable papers by Bone and co-workers and the excellent summary published by G. Egloff and R. E. Schaad on the Oxidation of the Gaseous Paraffin Hydrocarbons, in the *Chemical Reviews*, 1929. In this connection, J. N. Friend's small chemical monograph on *The Chemistry of Combustion* has also been valuable. Many of the mechanisms given by the author are simply suggestive and non-assertive and are meant to follow the course of the fumigation process.

For the last chapter, the author has derived help from S. Rideal and E. Rideal's *Chemical Disinfection and Sterilisation*, 1921, G. W. Askinson's *Perfumes and Cosmetics*, 1922, and F. A. Hampton's *The Scent of Flowers and Leaves*, 1925. A parallelism exists between the use of various fumigating pastils, powders, pencils, papers and wicks and the fumigating process of Agnihotra, and therefore, for comparison, the author has been tempted to reproduce a few of the formulæ for their preparations from Askinson's book and Henley's Twentieth Century Book of Recipes, Formulas and Processes, 1916, in the form of an appendix.

In another appendix, a list of aromatic veget-

able substances has been given which might be substituted for various products used in Agnihotra by way of tradition. Such substitutions are always permissible in the classical literature.

The author expresses here his deep gratitude to the authorities mentioned above for the help he has derived from their work. The author is also thankful to Prof. Dr. N. R. Dhar, the leading Indian Chemist and formerly the President of the Indian Chemical Society and the National Academy of Sciences, India, for kindly writing the Foreword. In a work like this, benedictions from our revered ex-Vice-Chancellor, Mahāmahopādhyāya Dr. Gangānātha Jhā, M.A., D.Litt., LL.D., an orientalist of eminence, have been very much encouraging. It is expected, that, though, incomplete, this monograph for the time being, will meet the purpose for which it has been written.

Kala-Kutir
Beli Road, Allahabad

Satya Prakash

CONTENTS

CHAPTER I

AGNIHOTRA: ITS VARIOUS ASPECTS

The five daily duties as prescribed by the Aryan scriptures are: *Brahmayajña* or the study of the Veda and devotion to the God, *Devayajña* or the purification through the process of fumigation or oblations to fire, *Pittriyajña* or homage to parents and other elders, *Atithiyajña* or duties towards guests, and *Bhūtayajña* or duties towards dependents, both men and animals. These are called five *Mahāyajñas* or the 'great performances' to be daily performed by all households, whether rich or poor, whether they be Brāhmaṇa, Kshattriya or Vaishya. In short, these duties include our duties towards the Creator, towards ourselves and other members of the society, and towards the world we live in. Performance of these *yajñas* means the living of life in full.

The object of writing the present book is to interpret the various details of *Devayajña* from the modern scientific point of view and to find out how far this daily practice could be of use to the health

and prosperity of an Indian household. In an attempt like this, one is likely to come across a number of such details which would lose all significance if adjusted to the modern environments or in some cases, might require a wholesome modification. However, the importance of *Deva-yajña* has been long realised, as Atharva-veda says (XIX, 55, 3-4): "Oblations offered to fire in the evening keep the household cheerful till the morning and those offered in the morning keep him cheerful till the evening." Taittiriyāraṇyaka (X, 63, 1) says that "Agnihotra performed morning and evening purifies houses. One such performed with care and attention is the best of the performances and is the light of the heaven." Swāmī Dayānand writes that "so long as the practice of this oriental process of fumigation was prevalent, in the Āryāvarta, the country was free from a number of diseases and enjoyed prosperity, and if even now introduced, it would again become so." (*Satyārtha-prakāsha*, Chap. 3). He further says that a substance when added to the fire diffuses out in the air in a rarefied form and displaces the foul air. There is an interesting dialogue between Janaka, an Indian Prince, and Yājñavalkya, the great seer, given in Upanishad:

Yājña.—O Prince, you know what Agnihotra is?
Janaka—Yes, I know it is the offering of milk products.
Yājña.—If milk be not available, what will you offer to the fire?
Janaka—Never mind. Rice and barley, Sir.
Yājña.—If rice and barley be also not available?
Janaka—Then other medicinal herbs.
Yājña.—In absence of these also?
Janaka—The forest herbs.
Yājña.—In absence of forest herbs?
Janaka—Vegetables, Sir.
Yājña.—When vegetables are also not procurable, then?
Janaka—Then purification by water alone.
Yājña.—In absence of water?
Janaka—Agnihotra is performed then even, the oblations are of TRUTH in the fire of FAITH.

All this when summed up means, that fire oblations consist of milk products, cereals, medicinal herbs, forest herbs, and vegetables, and ancestors had deep faith in the performance of Agnihotra under all circumstances.

Deva-yajña or Agnihotra, the common name of this oriental process of fumigation, is to an Ārya

something more than a mechanical and physical process. Besides being an important daily practice, it also becomes a central figure in a number of rituals and ceremonies. In fact, in an Āryan home, nothing becomes auspicious unless begun by Agnihotra. All the sixteen ceremonies or Samskāras are preceded with the kindling of fire and offerings to it. Besides Agnihotra in an individual home, there are congregational fires where similar sorts of offerings on a large scale are presented. On a full-moon day and on a no-moon day, and then on the beginning of every season or on some other auspicious *Parva*, Agnihotra should be performed with special dignity. Round the sacred fire, a hermit or saint gives metaphysical teachings to his disciples. In an ancient hermitage, the fire of life was synchronised with the fire of wood. There was hardly a home, the roofs of which were not coloured black by the smoke. Kings and emperors, in the Āryan period, took special delight in arranging with all *eclat* very big *yajñas*, and it was believed that by doing so, they would attain heaven. One who had performed one hundred *yajñas* was given the title of *Shatakratu* or *Indra*.

According to the Āryan Scriptures, the utility of Agnihotra may be summarised thus: (i) it

purifies air, (ii) it is a remedy for a number of diseases, (iii) it brings out timely seasons, (iv) it causes a healthy crop and furnishes a good harvest and lastly, (v) it is a compensation for various sins done unconsciously and unintentionally. It is beyond the scope of the present monograph to study Agnihotra in all aspects, but the author thinks that this practice of Indians is highly healthy and hygienic, and therefore, an attempt has been made to interpret it on a chemical basis.

The time prescribed for it

For the daily Agnihotra, the time prescribed is just on the sunrise in the morning after the performance of prayer and in the evening, just before the sunset. In fact, after the sun has set, the Agnihotra is ordinarily not permissible. A few of the special *yajñas* are prescribed after the sunset and in the night also. Most of the ceremonies are performed in the morning and therefore, usually the same is the time for fire offerings.

Place of an Agnihotra

The place for a *yajña* should be neat and clean, airy, spacious and free from wind disturbances. There should be a free approach of sunlight.

Swāmī Dayānand writes, that "the *Yajñashālā* or the *Yajñamandap*, (the place of sacred fire) should be at the maximum a plane square of 24 feet in length or at the minimum 12 feet. In case the ground be filthy, the whole of it should be dug 2 feet deep or as be necessary, and the filth be replaced with pure earth. For a 24 feet square, 20 and for a 12 feet square, 12 pillars in number be fixed and covered with a shade. The roof should be at least 15 feet high above the fire surface. There should be four doors in the four directions and all round, the place should be decorated with buntings, flags, leaves and flowers. The floor should be daily washed and painted with cow-dung and then the line drawings be carved with flour, turmeric powder, kumkum and other colours." The yajñashālā, instead of being a square, may be octagonal also.

Dimensions of the Yajñakuṇḍa

The dimensions of the fire-pot vary with respect to the number of oblations, which amount to only 25 for daily Agnihotra but in special cases, may be extended to one hundred thousands also. Ordinarily, the pots made of copper or iron are available, or the ground is dug in a reverse pyramid

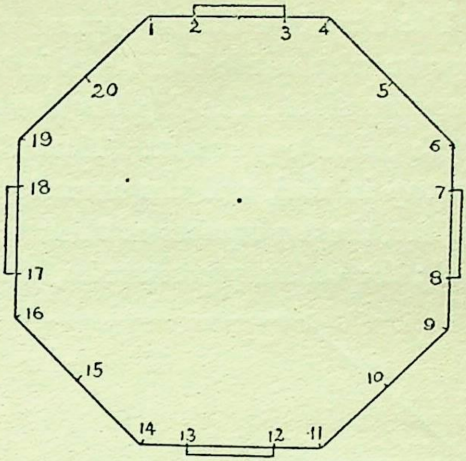


Fig. 1—An octagonal section with 20 pillars.

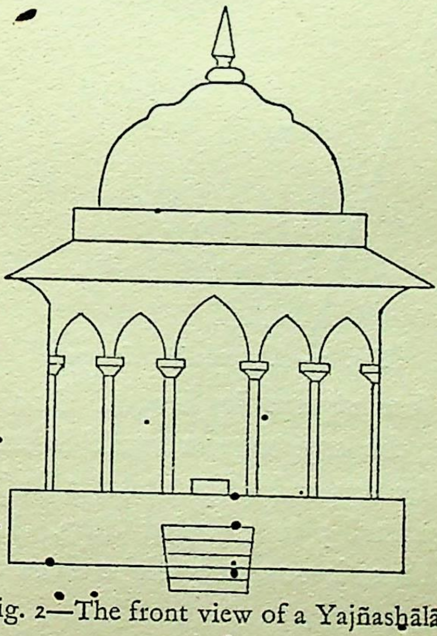


Fig. 2—The front view of a Yajñashālā.

fashion. The base is a narrow square while the top is a square with a side four times in length of the base square side. The depth is also the same as the length of the top square. Thus if the base be a^2, the top is $16a^2$, and the normal depth $4a$. For big *yajñas*, the top squares of 8 feet length are constructed; for ordinary ceremonies, they are of

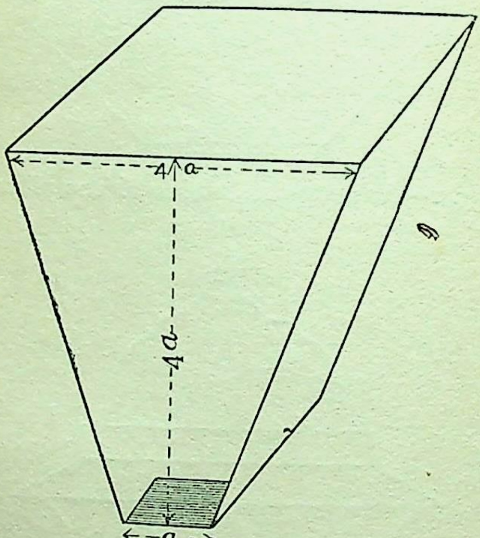


Fig. 3—A pyramidal fire-pot.

about 2 feet square in length. For the daily Agnihotra, the copper pots available are 6 inches square at the top and some about 2 inches square at the base and 3 to 5 inches deep. In most of the cases, there is one steep slope from top to the

base but in some cases the pot is narrowed down from top to the base in 3 regular steps, the side wall always remaining perpendicular as has been shown in figure 4.

Utensils for Yajña

The utensils for the performance of Yajña or Agnihotra are generally of brass, bronze, copper,

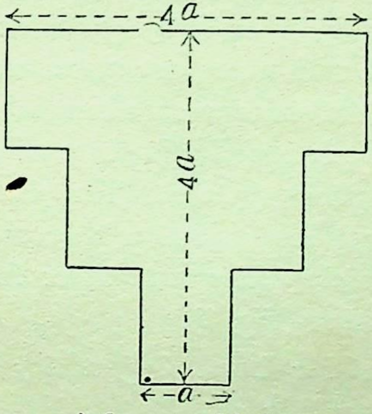


Fig. 4—A fire-pot with three steps.

silver or wood. Aluminium pots may also be used. They consist of saucers, plates, ladles, trays, dishes, beakers, tongs, pestle and mortar, sieves etc. The following are a few of the utensils mentioned in old books :

1. Four ladles (*Srucha*) about two feet in length each (usually one ladle suffices for pouring butter) :

(a) *Juhū* made of Dhāk wood (Butea frondosa).

(b) *Upabhrita* of Pīpal wood (Ficus religiosa).

(c) *Dhruvā* of Vikankata wood (Gymnosporia montana).

(d) *Sruva* of Khadir wood (Uncaria gambier).

2. *Panchapātra* or *Praṇītāpātra*, or five copper beakers filled with water, one placed on each corner of the fireplace and one on the main seat near the butter pot for *huta-shesha* (leavings of an oblation). Five small spoons (*Āchamanī*) in the five beakers (Fig. 6 and 7). *Prokshaṇīpātra* is a vessel with spout for conveniently taking out water for sprinkling and consecrating (Fig. 8).

3. One big bowl (*Ājyasthālī*) for keeping clarified butter (Fig. 9).

4. Three metal dishes or large plates, for keeping offerings (Fig. 10).

5. Four or five mat-seats made of grass, wool or wood (20″ in length) (Fig. 11).

6. One or two sets of *Musal* or pestle and *Ulūkhal* or mortar (Fig. 12 and 13).

7. One *Drishad* or flat stone piece and one *upal* or stone cylinder (Fig. 14 and 15) for powder-

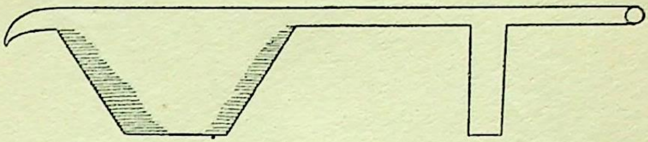


Fig. 5—Srucha.

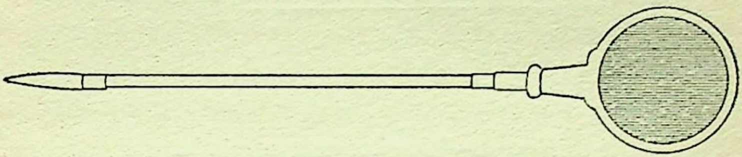


Fig. 6—Āchmani.

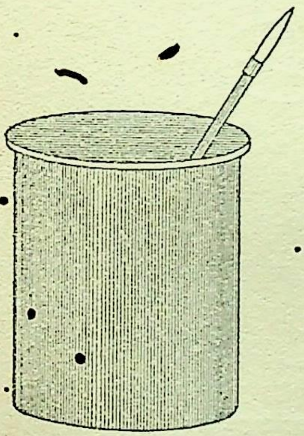


Fig. 7—Panchapātra.

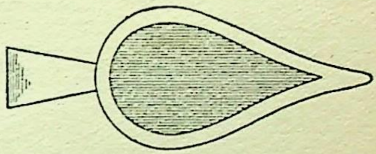


Fig. 8—Prokshaṇipātra.

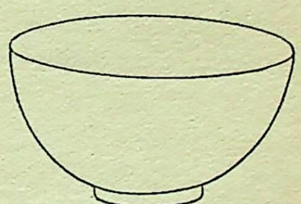


Fig. 9—Bowl or Ājyasthālī.

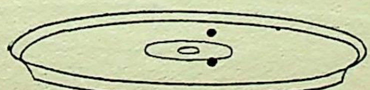


Fig. 10—Plates or sthālī.

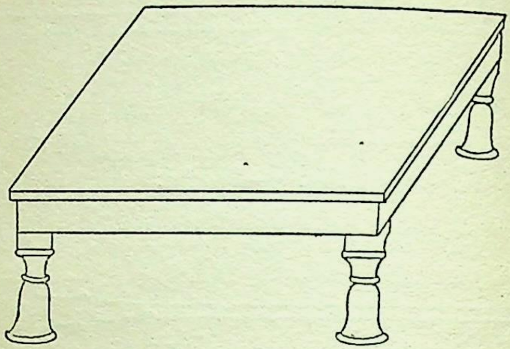


Fig. 11—Wooden seat or pātala.

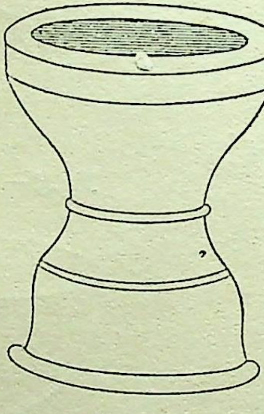


Fig. 12—Ulūkhal or mortar.

Fig. 13—Musal or pestle.

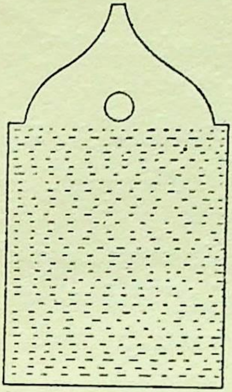


Fig. 14—Drishad.

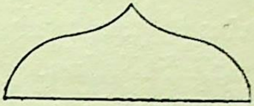


Fig. 15—Upala.

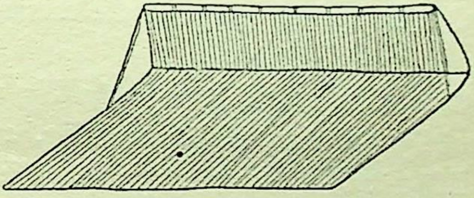


Fig. 16—Shūrpa.

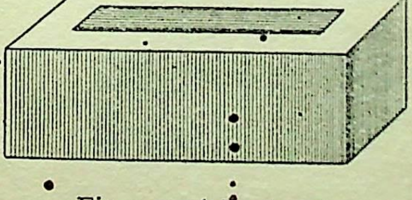


Fig. 17—Adharāraṇi.

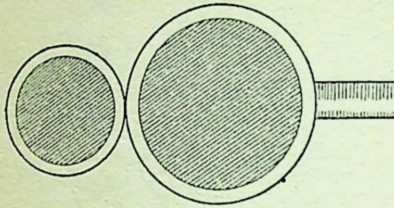


Fig. 22—Iḍā-pāttra.

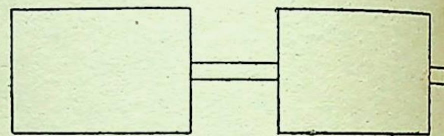


Fig. 23—Ṣaḍavata.

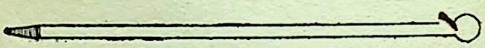


Fig. 24—Abhri.

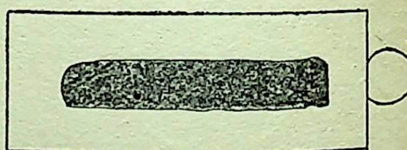


Fig. 25—Chāttra.

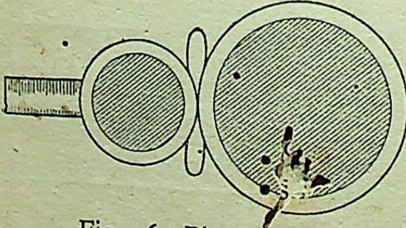


Fig. 26—Piṣṭa-pāttrī.

16. *Abhri* or a wooden scraper or sharp pointed stick for cleaning (Fig. 24).

17. *Çhāttra* or a cylinder of catechu-wood used in producing the fire, now no longer used (Fig. 25).

18. *Piṣṭa-pāttrī* or a vessel for keeping flour oblations, ground and kneaded (Fig. 26).

19. Four jugs full of water at the four corners of the fire-canopy with four earthen dishes with butter and cotton wicks for light.

Nowadays, according to convenience, almost all the utensils have changed their classical shapes to the modern designs of a Hindu family. Fire is no longer mechanically produced by rubbing two pieces of wood against each other and the recourse is taken to a modern safety match box. Ordinary metallic tumblers, bowls and plates which are used in an Indian kitchen are generally utilised. Earthen pots are also very convenient. China clay, porcelain, glass or enamelled vessels have not yet found a place. There appears to be no prejudice against aluminium and German silver vessels.

Participators in an Agnihotra

Agnihotra is more or less a family affair. In an ideal home, husband and wife with children all

jointly perform this daily ceremony. In fact, wife plays a very important part and no ceremony or function without her is supposed to be done to the perfection. She arranges for all the details. It becomes her duty to see that everything has been done neatly and fire oblations prepared with due attention. In an old tradition, the fire which was adorned on the day of marriage continued to burn without being ever allowed to extinguish throughout the couples' life or at least till one leaves the world for the forest life or the life of renunciation. This fire symbolised in a way the fire of life.

For the daily performance of the Agnihotra the number of people partaking is not fixed. Even if one be alone he should do it. Agnihotra is obligatory to a *Dvij* (Brāhmaṇa, Kshattriya and Vaishya) household and also to a Vānaprastha or the forest-dweller, and is optional to one who is either a student (Brahmachārī) or one renounced (Sanyāsin). Brahmachārī performs it along with his teacher and co-disciples in hermitage or with parents in a family.

For a congregational Agnihotra performed on some special occasion, there are four seats fixed for four people in four directions, and each one has got a technical name.

(i) *Hotā* on the west seat, facing towards the east.

(ii) *Adhwaryu* on the north seat, facing towards the south.

(iii) *Udgātā* on the east seat, facing towards the west.

(iv) *Brahmā* on the south seat, facing towards the north.

Yajamāna or the family head who performs the Agnihotra usually becomes the Hotā and occupies his seat on the west facing east. Or he might take a separate seat on the south facing north. One who guides the ceremony and is well versed in the rituals is called *Purohita*. He either sits separately on a fifth seat or takes the place of *Brahmā* on the south. Wife usually sits on the left side of the husband along with him.

Arrangement of wood

Dried wood, free from insects and worms is cut into small sticks of varying dimensions according to the size of Agnikunḍa or the fire-pot. It has already been said that the fire-pot is of a pyramidal shape with apex downwards. If the pot is of copper, a thick layer of sand-free earth is laid and on it is placed the pot, supported preferably by clay

or bricks the
with small wooden

 arranged

jointly perforne base of the pot is wholly covered plays a very wooden splinters, and other sticks are furanged over it forming squares one above the the other. A few of the sticks are also placed diagonally and crosswise. There remains a central core from top to the base with almost no packing of wood with only a few thin splinters here and there. About three-quarters of the fire-pot is packed up with wood in the beginning while the additional sticks may be placed from time to time according to requirement during the performance.

If the fire-pot is constructed by digging the ground, a narrow drain of about an inch width is made to go round the pot. It is filled with water after the fire has been kindled. The water prevents insects and worms from creeping in into the fire.

It may be remarked here that in the fire-pot, the packing of wood is neither so dense as to prevent fire from coming in contact with air, nor so loose as to get an excessive supply of air. The fire-pot is open only from the top while all the four sides are covered. As will be pointed out afterwards, this point is highly essential to have an effective fumigation.

Wood for fire

The following wood is prescribed for fire :

1. *Sandalwood*: This is the most esteemed wood, though it can-not be used by ordinary people on account of its high price. It might be used in part.

2. *Agar* and *Tagar wood*: This wood is also pretty costly but is very suitable for Agnihotra especially in conjunction with other wood.

3. *Pine wood or Deodar*: Amongst the 'essential' woods, pine is the cheapest. Moreover, it has the quality of being easily inflammable.

4. *Mango wood*: High quality of mango wood is always procurable in India.

5. *Dhāk or Palāsh* (Butea Frondosa): The thin stems are easily inflammable. The wood can be dried with ease, and the fire glow is continuous. In this respect, it appears to be one of the best for the purpose.

6. *Bilva* (Aegle marmelos): It also burns easily and is noted for some of its volatile constituents.

7. *Shamī* (Prosopis spicigera).

8. *Pīpal* (Ficus religiosa).

9. *Baṛh* (Ficus bengalensis).

The wood, in any case, should be easily pro-

curable and should burn without difficulty. I should give no disagreeable or disgusting odour while burning. Pungent woods, especially alkaloidal ones, are out of question, and those with essential constituents are always preferred.

Care is taken that the wooden pieces are clean and free from dust, refuge and insects. In some cases, barks are not desirable as they catch fire with difficulty and sometimes give obnoxious fumes.*

*In Vāyu Purāṇa, wood prescribed for Homa is of the following trees :

Palāsha (Butea frondosa); Phalgu, Udumbar or Yajñadumbar (Ficus glomerata, Roxb.); Nyagrodha or Barhga (Ficus bengalensis, Linn.); Plaksha, Ashwattha (Ficus arnottiana, Miq.); Ashwattha or Pīpal (Ficus religiosa, Linn.) Bilva or Bael (Aegle marmelos or N. O. Rutaceæ); Chanda or Sandalwood; and Vikankat (Gymnosporia montana) Devadāru (Cedrus libani, Barrel); Shāla (N. ovalifolia, Roxb.) and Khadir (A. catechu) are also preferred. On special prescription by experienced elders, even a thorny wood can be used.

According to Kattyāyana, sticks thicker than the thumb, without bark, with insects and worms, and splintered should not be used.

According to Mittra Parishishttha, woods prescribed are Palāsha, Ashwattha ; Khadira ; Rohitaka (Amoora rohituka, W. and A. Meliaceæ) ; Udumbara (Gūlar) ; and when these not procured, Tinduka (Diospyros embryopteris) Dhavala (Lobelia nicotianæfolia Heyne) ; Āmra or Mango (Mangifera indica Linn); Nimba or Neema (Melia azadirachta Linn.) ; Shālmali (Morus indica) ; Aratna ; Kapittha or Kaith (Feronia elephantum Correa ; Rutaceæ) ; Kovidāra or Kachnar

Offerings to fire

Swāmī Dayānand has classified all the offerings to fire into four groups :

I. Substances with fine odour : (Odoriferous).

(i) Musk.
(ii) Saffron.
(iii) Agar—Aquilaria Malaccensis.
(iv) Tagar—Valeriana Wallichii.
(v) Chandan — Sandalwood — Santalum Album.
(vi) Ilāyachi—Elettaria Cardamomum and also the Greater Cardamom, the Amomum Subulatum.
(vii) Jāyaphal—Nutmeg or Mace—Myristica Fragrans.
(viii) Jāvitrī.

II. Substances with healthy constituents : (Substantious).

(Bauhinia variegata Linn.) ; Vibhitaka or Baherhā (Terminalia belerica Roxb). Shleshmataka or probably Chhoṭālasorhā or Bahubarā (Corchorus obliqua Willd) ; in fact, any wood is permissible provided it has no thorns.

Vāyu Purāṇa does not permit of wood which is thoroughly dried or which is old, without bark, small, crooked, full of holes, very thin or very long or very thick or eaten up by Ghuṇa. Slightly moist fresh wood covered with sugar and butter is very desirable.

(i) Ghrita—clarified butter.
(ii) Milk.
(iii) Fruits.
(iv) Roots (Kanda).
(v) Cereals or grains as rice, wheat, peas etc.

III. Sweet substances :
(i) Sugars.
(ii) Honey.
(iii) Dried grapes.
(iv) Chhuhārā.

IV. Medicinal herbs :
Somalatā or Giloya—Tinospora Cordifolia.

Swāmī Dayānand has described some special preparations also as cooked rice, rice cooked in milk and sugar added, sweet preparations of milk, butter and flour (round sweet balls), Mohanabhoga, etc. Mohanbhoga consists of 1 seer of crystalline sugar, 1 ratti musk, 1 masha saffron, 2 mashas, Jāyaphal.

According to Shaṭ-trinshan-mata, the seven grains permissible for offerings are :
(i) Yava or Barley.
(ii) Godhūma or wheat.
(iii) Dhānya or rice.

(iv) Til or sesamum indicum.
(v) Kangu or Kangani or Setaria italica.
(vi) Mudgaka or Mūnga or Phaseolus mungo, Linn.
(vii) Chaṇaka or Chanā or Cicer arietinum Linn.

Hemādra prescribes the following grains :

1. Barley.
2. Wheat.
3. Rice.
4. Til or sesamum.
5. Kangu.
6. Kulattha or Dolichos biflorus Linn.
7. Māsha or Urhada or Phaseolus radiatus.
8. Mudgaka or Mūnga.
9. Masūra or Ervum lens linn.
10. Nishpāva or Lobiā or Vigna catiang, Endl.
11. Shyām sarshap or black mustard.
12. Gavedhuka, gurlu or gurmur or Coixlachryma Linn.
13. Nīwāra.
14. Āḍhakya or Arahar (Cajanus indicus Spreng).
15. Satīnakā or Maṭar or peas.
16. Chaṇaka or chanā.
17. Chinaka (Chainā).

Nowadays, 'Havana Sāmagrī' or the fumigating

mixture for fire oblations obtained in market usually contains the following substances in a crude powdered form :

1. Sandalwood saw-dust.
2. Pinewood saw-dust or Deva-dāra.
3. Powdered Agar wood chips—Aquilaria malaccensis, Lamk.
4. Powdered Tagar wood chips-Valeriana wallichii, D. C.
5. Kapūr Kachrī—Hedychium spicatum, Ham.
6. Gūgal - Boswellia serrata, Roxb.
7. Nāgarmothā—Cyperus scariosus, R. Br.
8. Bālchhar—Nardostachys valerianeæ or Jatamansi, D. C.
9. Nar-Kachurā—Curcuma cæsia, Roxb.
10. Sugandhabālā—Pavonia odorata.
11. Ilāyachī—the lesser and greater cardamom
12. Jāyaphal—Nutmeg or Mace—Myristica fragrans.
13. Lavanga—Cloves or Eugenia caryophyllata.
14. Dārchīnī—Cinnamomum cassia.

Usually, for Agnihotra on a large scale, four dishes are arranged to be placed in the four directions :

(A) One bowl full of clarified butter preferably of cow, otherwise of she-buffalo. It is melted, filtered and a little saffron also added to it.

(B) One big dish full of 'Havana Sāmagrī' or the fumigating-mixture described above. Sugar to an extent of about 25 per cent is also added and a little clarified butter also mixed.

(C) One dish full of dried fruits:

(a) Makhānā - Nymphæaceæ or Euryale ferox.
(b) Gari - Dried cocoanut cut in small pieces.
(c) Chhuhārā or dates.
(d) Kishmish or raisins.
(e) Bādām—Almonds.
(f) Chironjī—Buchanania latifolia.
(g) Munakkā or dried grapes.

Nuts as Kājū (Anacardium occidentale), Mūngphalī (Arachis hypogæa), Akhrota (Aleurites moluccana), and other dry fruits as Pishtā (Pistacia vera) and Chilgozā (neoza) may also be taken.

(D). One dish of grains:

(a) Til or sesamum, black and white.
(b) Rice.
(c) Barley.

These are the three very common grains, but sometimes other grains which have been described before may also be added. Fresh grains at the time of harvest are also prescribed as offerings.

Fresh fruits which are not very sour and do not contain a large amount of free water are also sometimes added but not very often.

Various kinds of sweets prepared from milk products, flour and sugar, rice cooked in milk, and other rich preparations which do not contain salt, spices, and other acrid and pungent material may also be offered on special occasions.

The daily Agnihotra consists of the offerings of the 'Havana Sāmagrī' (the fumigating mixture) above described and a little sugar and clarified butter.

The kindling of fire is initiated ordinarily by burning camphor. On special occasions, at the four corners of the altar are placed four big earthen pitchers, mouths of which are covered with earthen dishes containing cotton wicks and melted butter. The wicks are lighted up with match sticks, and then these wick flames are utilised for initiating fire in splinters. Needless to say, that the ancient tradition to obtain fire was by mechanically rubbing two pieces of wood, but now, since

match sticks are in vogue, this method is almost extinct and is only seen on very rare occasions in some orthodox homes.

The Actual Process

The actual process of performing Agnihotra is very rhythmical. Before a householder performs it, he should sweep up the floor, or wash it up with water. In case the floor is of mud, he should paint it with cowdung. All the utensils are neatly cleaned, and wood sticks carefully selected. The fumigating mixture, butter and other offerings are carefully examined so that no dirt, worm or insect passes into it.

The householder then takes up a full bath in cold or hot water, and dresses himself only in one piece of cloth called *dhotī*, about 5 or 6 yards in length with which he covers his body loosely. During the time of Agnihotra performed in open air or in airy room, most portion of his body is exposed to sun and air. His *dhotī* is washed with water daily after bath and allowed to dry in sun. This practice keeps the cloth clean and free from harmful bacteria.

Chants of Hymns: Usually the time of Agnihotra is just on the sun-rise, in the morning. Just

before this, the household person is expected to have finished his morning prayer which comprises of the recitations of Vedic hymns, describing glory of the God, and asking for the blessings from Him and success through life. He is also expected to perform breath-exercises, or *prāṇāyāma*, for physical and mental purity.

Now, the rhythm of various actings during the performance of actual Agnihotra is regulated by chanting hymns. By doing so, the monotony of the process is shaken off and sanctity is also added which plays a very important rôle in keeping up a psychological interest in a process which would have been otherwise a merely mechanical one. These hymns sometimes describe the process, sometimes the utility of the process and sometimes they are prayers to God. The symbolic fire sometimes represents the fire of life or sometimes the cosmic fire which regulates the whole of the Universe. The author of the present book, is, however, not concerned here with the details of the hymns. He would simply like to impress, that the chant of the hymns is very rhythmical and helps a lot in regulating fire. An offering is made, only at the conclusion of one hymn or aphorism and not in the middle of it just after the pronouncement of

the syllable "SVĀHĀ." It has been the personal experience of the author that the period of hymns and aphorisms is so chosen that it gives sufficient time for the fire to get itself regulated according to the offerings, and the whole process goes on progressing very healthily without interruption. A continuous shower of offerings would have disturbed the fire, it might extinguish it altogether and would not allow the proper combustion.

The details of performing Agnihotra may vary in some features from time to time and according to the means of the person performing. But, however, there are two essential parts :

(i) Sāmānya Prakaraṇa or the General Feature.

(ii) Vishesha Prakaraṇa or the Special Feature.

It is only the special feature which is changeable while the Sāmānya Prakaraṇa, the general one, more or less remains the same.

In order to comprehend the significance, an attempt will be made here to sketch out the General Feature of the Agnihotra ceremony as it is daily performed.

I. *Āchamana Prakriyā*[1]

(Sipping Water Process)

A little water about 2 to 5 c.c. taken on the right palm and sipped three times at the conclusion of each of the following aphorisms.

1. O immortal water, thou art shelter from the below.

   (First sip)

2. O immortal water, thou art shelter from the above.

   (Second sip)

3. Let the truth, the fame and the wealth be always in me.

   (Third sip)

Here water symbolises the God and all the aphorisms are addressed to Him.

[1] Om Amṛtopastaraṇamasi SVĀHĀ.
Om Amṛtāpidhānamasi SVĀHĀ.
Om Satyam Yaśaḥ Śrīrmayi Śriḥ Śrayatām SVĀHĀ.

(Mānava. 1, 9, 15-1

II. *Angasparsha Prakriyā*[1]

(Touching Body Process).

A little water taken on the left palm and sprinkled by the three middle fingers of the right hand on different parts of the body as given below:

1. O God, Let speech reside in my mouth. (*Sprinkle on the lips*).
2. Let breath reside in my nose. (*On the nose*).
3. Let sight reside in my eyes. (*On the eyes*).
4. Let hearing reside in my ears. (*On the ears*).
5. Let there be strength in my arms. (*On the arms*).
6. Let there be power in my thighs. (*On the thighs*).
7. Let my body and all parts of my body be healthy. (*On the whole body*).

[1] Om Vāṅ Ma Āsye-stu.
Om Nasorme Prāṇo-stu.
Om Akśṇorme Chakśurastu.
Om Karṇayorme Śrotramastu.
Om Bāhvorme Balamastu.
Om Ūrvorma Ojo-stu.
Om Ariśṭāni Me-ṅgāni Tanūstanvā Me Saha Santu.
(Pāraskara, 1, 3, 25).

III. *Agnyādhāna Prakriyā*

(Initiation of Fire).

1[1]. O God, thou art the creator, maintaine
and giver of happiness.

(With this aphorism the flame from a match stick applied to camphor placed in a spoon).

2[2]. O earth, the place where all gods perfor sacrifices, on thy back, for the production edible harvest, I am placing the all-eating fir I in glory be like this sky and in span be like th earth.

(With this hymn, the kindled camphor be placed side the firepot, with all the people standing).

3[3]. O fire, get you up, be awakened. Yo and he (this householder) both jointly may fu the desired auspicious work. On this and ev the better place, all the learned people along wi the householder may sit down.

[1] Om Bhūr Bhuvaḥ Svaḥ. (Gobhil 1, 1, 11).

[2] Om Bhūr-bhuvaḥ Svardyauriva Bhūmnā Pṛthiv Varimṇā Tasyāste. Pṛthivi Devayajani Pṛṣṭhe-gnimannā mannādyāyādadhe. (Yajuḥ 3, 5)

[3] Om Udbudhyasvāgne Pratijāgṛhi Tvamiṣṭapūrte (gvam) sṛjethāmayaṃ Cha. Asmin Sadhasthe Adhyutta min Viśvedevā Yajamānaścha Sīdata.—(Yajuḥ. 15, 54).

(With this hymn, the fire is adjusted, and then all the people sit down).

IV. *Samidhādāna Prakriyā*

(Placing of the Firesticks).

With each of the three following hymns, three sticks about eight fingers thick in length dipped into clarified butter be placed on the fire.

1[1]. O people, you should always feed fire, the guest, with sticks, and awaken it with butter. Put into the fire the offerings, SVĀHĀ. (*Place one stick in the fire*).

It is for the fire and not for me.

2[2]. For the well-burnt and kindled fire, offer the molten butter. For the fire, the source of all, SVĀHĀ. (*Place the second stick*). It is for the fire the source of all and not for me.

3[3]. O all-pervading fire, it is to you that we encourage with sticks and butter. You are always

[1] Om Samidhāgnim Duvasyata Ghṛtairbodhayatātithim. Āsmin Havyā Juhotana SVĀHĀ. Idamagnaye, Idanna Mama. (Yajuḥ. 3, 1).

[2] Om Susamiddhāya Śochiṣe Ghṛtam Tībram Juhotana. Agnaye Jātavedase SVĀHĀ. Idamagnaye Jātavedase, Idanna Mama. (Yajuḥ. 3, 2).

[3] Om Tantvā Samidbhiraṅgiro ghṛtena Vardhayāmasi. Brihachchhochāyavisṭhya SVĀHĀ. Idamagnayem-girase, Idanna Mama.—(Yajuḥ. 3, 3).

young. Kindle you up, SVĀHĀ. (*Place the th*
stick).

It is for the all-pervading fire and not for me.

V. *Rousing of the Fire*

The following hymn[1] is to be repeated five times and ea
time one offering of clarified butter given.

O fire, the source of all, this fuel is your soul
with its help, be aroused and inflamed. Envigor
ate us also. Make us prosperous with children
and cattle, with grandeur, and the health fo
digestion, SVĀHĀ. It is for fire, the source o
all and not for me.

VI. *Sprinkling of Water round the Fire*

With the following aphorisms,[2] water is sprinkl
round the fire. In case, a regular narrow drain has be
constructed round the fire-pot, water is filled up in it n
with the following aphorisms. This partly subsides the v
our of fire and also saves the pot from the incoming
insects from outside.

[1] Om Ayanta Idhma Ātmā Jātavedastenedhyasva V
dhasva Cheddhavardhaya Chāsmān Prajayā Pashubh
Brahmavarchasenānnādyena Samedhaya SVĀHĀ. Idam
gnaye Jātavedase Idanna-Mama. (Aśvalāyana, 1, 10, 12).

[2] Om Adite-numanyasva.
Om Anumate-numanyasva.
Om Sarasvatyanumanyasva.—(Gobhila, 3, 1-3).

1. O indivisible God, Let us be unto you. (*In the east*).

2. O the law abider God, Let us be according to you. (*In the west*).

3. O the source of knowledge, Let us be according to you. (*In the north*).

4[1]. O the creator, the source of light, fulfil the Yajña, and lead the sacrificer to prosperity. The one who is light, the upholder of all, purifier of the knowledge, may purify our intellect and O the master of speech, make my speech sweet. (*With this sprinkle in all directions*).

VII. *Āghārāvājyāhutī*

(Offerings of Molten Butter)

The four offerings of molten butter with the following four aphorisms.[2]

1. With homage to the all glorious God,

[1] Om Deva Savitaḥ Prasuva Yajñam Prasuva Yajñapatim Bhagāya. Divyo Gandharvaḥ Ketapuḥ Ketanna Punātu Vāchaspatirvācham. Naḥ Svadatu. (Yajuḥ. 30, 1).

[2] Om Agnaye SVĀHĀ. Idamagnaye, Idanna Mama.
Om Somāya SVĀHĀ. Idam Somāya, Idanna Mama.
Om Prajāpataye SVĀHĀ. Idam Prajāpataye, Idanna Mama.
Om Indrāya SVĀHĀ. Idamindrāya Idanna Mama.—(Yajuḥ. 22, 27).

SVĀHĀ. (*In the north of the pot*). It
for the glorious God and not for me.

2. With homage to the all peace loving Go
SVĀHĀ. (*In the south of the pot*). It is f
the peace loving God and not for me.

With the following two, in the middle of the pot:

3. With homage to the Lord of all, SVĀHĀ
It is for the Lord of all and not for me.

4. With homage to the Graceful Go
SVĀHĀ. It is for the Graceful God and n
for me.

VIII. *Offerings of Fumigating Mixture alo with Butter*

(For the Morning Fumigation)

One person should offer butter and all others fumigati mixture and other articles.

1.[1] The Sun, the Light : the Light, the Sun,
SVĀH

2. The Sun, the Grand : the Light, the
Grand, SVĀH

3. The Light, the Sun : the Sun, the Light,
SVĀH

[1] Om Sūryo Jyotirjyotiḥ Sūryaḥ SVĀHĀ.
Om Sūryo Varcho Jyotirvarchaḥ SVĀHĀ.
Om Jyotiḥ Sūryoḥ Sūryoḥ Jyotiḥ, SVĀHĀ.—(Ya
3, 9).

4.[1] In conjunction with the Light and the Sun, and in conjunction with the Grace and the Dawn, let the Sun be blessed to us, SVĀHĀ.

(For the Evening Fumigation)

Offerings of fumigating mixture and butter.

1.[2] The Fire, the Light : The Light, the Fire, SVĀHĀ.

2. The Fire, the Grand : The Light, the Grand, SVĀHĀ.

3. The Fire, the Light : The Light, the Fire, SVĀHĀ.

4.[3] In conjunction with the Light and the Sun, and in conjunction with the Grace and the Night, let the Fire be blessed to us, SVĀHĀ.

IX. *Oblations for Morning and Evening both*

Offerings of fumigating mixture and butter both.

1.[4] For the Creator, the Fire, and the Vital

[1] Om Sajūrdevena Savitrā Sajūruṣasendravatyā Juṣanaḥ Sūryo Vetu SVĀHĀ. (Yajuḥ., 3, 10).

[2] Om Agnirjyotirjyotiragnịḥ SVĀHĀ.
Om Agnirvarcho Jyotirvarchaḥ SVĀHĀ.
Om Agnirjyotirjyotiragniḥ SVĀHĀ.—(Yajuḥ, 3, 9).

[3] Om Sajūrdevena Savitrā Sajūrātryendravatyā Juṣaṇo Agnirvetu SVĀHĀ.—(Yajuḥ. 3, 1).

[4] Om Bhūragnaye Prāṇāya SVĀHĀ. Idamagnaye Prāṇāya, Idanna Mama.

Breath, SVĀHĀ. It is for the Fire and the Vi Breath and not for me.

2.[1] For the Sustainer, the Air, and th Lower Breath SVĀHĀ. It is for the Air, and th Lower Breath and not for me.

3.[2] For the Blessed, the Sun and the Pervad ing Breath, SVĀHĀ. It is for the Sun and th Pervading Breath and not for me.

4.[3] For the Creator, the Sustainer and th Blessed, For the Fire, the Air and the Sun, Fo the Vital, the Lower and the Pervading Breath SVĀHĀ. It is for the Fire, the Air, the Sun, th Vital, the Lower, and the Pervading Breaths an not for me.

5.[4] Thou art Omnipresent, O God, thou a light, the essence, the immortality, the Great, th Creator, the Sustainer and the source of all jo SVĀHĀ.

[1] Om Bhuvarvāyave-pānāya SVĀHĀ. Idam Vāyv pānāya, Idanna Mama.

[2] Om Svarādityāya Vyānāya SVĀHĀ. Idamādityā Vyānāya, Idanna Mama.

[3] Om Bhūrbhuvaḥ Svaragni-vāyvādityebhyaḥ Prā pānebhyaḥ SVĀHĀ. Idamagnivāyavādityebhyaḥ Prāṇāpā vyānebhyaḥ, Idanna Mama.

[4] Om Āpo Jyotī Raso-mṛtam Brahma Bhūrbhu Svarom SVĀHĀ.

6.[1] O God, the Source of all light, the very intellect and consciousness, which the learned and elders both valued, with the very intellect, make me now gifted, SVĀHĀ.

7.[2] O God, the Light and the Creator, let all that is evil in us, the source of all pain, be removed, and all that is good be given to us. SVĀHĀ.

8.[3] O God, the Light and the Knowledge, You are the knower of all the Laws; For the eternal bliss, lead us to the path of righteousness, and from us take all that is crooked and sinful. May we always express our deep gratitude to you. SVĀHĀ.

9.[4] And now, verily, all this has come to an end, the perfection. SVĀHĀ.

[1] Om Yām Medhām Devagaṇāḥ Pitaraśchopāsate. Tayā Māmadya Medhayāgne Medhāvinam Kuru SVĀHĀ. (Yajuḥ. 32, 14).

[2] Om Viśvāni Deva Saviturduritāni Parāsuva. Yadbhadrantanna Āsuva SVĀHĀ. (Yajuḥ. 30, 3).

[3] Om Agne Naya Supathā Rāye Asmān Viśvāni Deva Vayunāni Vidvān. Yuyodhyasmajjuhuraṇameno Bhūiṣṭhānte Nāma Uktim Vidhema SVĀHĀ. (Yajuḥ. 40, 16).

[4] Om Sarvam Vai Purṇa (gvam) SVĀHĀ.

CHAPTER II

FUMIGATING SUBSTANCES: THEIR ANALYSES

A. *Analysis of Wood*

Cellulose and ligno-cellulose are generally the principal constituents of all sorts of wood. In addition to them, there may be present in small amounts gums, resins and a number of allied bodies together with numerous inorganic salts. The following appears to be an average composition of a number of woods:

Carbon	48 to 50 per cent
Hydrogen	6
Nitrogen	0.04 to 0.1
Oxygen	43 to 45
Ash	0.3 to 0.6

Many of the woods are prized for their essential constituents as pine wood, sandal wood, agar and tagar woods. Woods have got a lower calorific value, about 4500 to 5200 calories, compared to coal or other fuel products. The temperature

attained during burning of wood hardly exceeds 500°C.

Tannin forms an important constituent of barks.

Some of the woods which give out oily or essential constituents during the fumigation process have been described in details in the following pages while a mention may also be made here of them which mainly act as fuel and burn without giving any obnoxious odour.

1. AMB—Mangifera Indica, Linn.

Vernacular names—Ām (Hindi), Amba (Mar.), Mangamaram (Tam.), Ambaj (Arab.), Ambo (Guj.), Ma (Mal.).

The wood contains in almost equivalent amounts cellulose and lignocellulose. The bark contains tannin.

2. ĀMRA—Spondias Mangifera, Willd. (Wild mango).

Vernacular names—Āmbrā, Āmrā (Hindi, Beng.), Ambada (Mar.), Mari-manchedi (Tam.), Toura-mamidi (Tel.), Pundi (Can.). Also called Amrataka or Amrat in Sanskrit.

3. BABŪL—Acacia Arabica, Willd.

Vernacular names—Babūl, Kīkar (Hindi), Babhul (Mar.) Babul (Beng.), Baval (Guj.), Karijali (Can.), Kuruveylam (Tam.).

The bark contains 22.44 per cent tannin.

4. BARGAD—Ficus Bengalensis.

Vernacular names—Bath, Bargad (Hindi, Beng., Gu Vara, Vari (Mar.), Ala (Tam.), Mari, Peddim (Tel.), Aldamara (Can.). It is also known as V or Nygrodha in Sanskrit.

The ordinary composition of the wood is the same, whereas the bark contains 10.9 per cent tannin, and the dried sample leaves about 8 per cent of the ash.

5. GŪLAR—Ficus Glomerata.

Vernacular names—Gūlar, Udambar (Hindi), Jagn-dumar (Beng.), Atti (Tam.), Moydi, Atti (Te Kullakith (Can.), Umbara (Mar.), Umbro (Guj.).

The bark contains 14 per cent of tannin an leaves about 12.2 per cent of the ash.

6. NIMB—Mellia Azadirachta, Linn.

Vernacular names—Neem, Nimb (Hindi), Nim (Beng Nimb, Batatanimb (Mar.), Bevina-mara, Isabe (Can.), Nimbamu, Vepachetta (Tel.), Vembu, Vepp (Tam.), Limbado (Guj.).

It is also known as Arishta in Sanskrit.

This tree is frequently planted as a homest or avenue tree as it is believed to purify air. Almos every part of this tree is used for medicinal purpo in India. Under the name of *panchāmrita*, a me

cine is prepared which contains the bark, fruits, flowers, leaves and root of the tree. The bark contains a bitter principle which may be alkaloidal (Cornish, 1856) or a resin (Broughton, 1873). The seeds contain a fixed bitter oil of deep yellow colour, specific gravity 0.9235 at 15.5°C (Warden). The oil contains free and volatile fatty acids; it also contains 0.427 per cent sulphur (Roy and Chatterji, 1917, Ind. J. Med. Res. Vol. V. p. 656). Neem oil in minute traces appears to be also present in the neem wood. The peculiar odour of neem is chiefly due to organic sulphur compounds which are slightly volatile (Watson, 1923, J. Soc. Chem. Ind., Vol. 1, p. 387). Dutt and coworkers (1930), however, consider that the odorous element in the oil consists of an evil smelling essential oil which remains dissolved in the oil itself and cannot be easily fractionated.

The pharmacological action of the oil has been investigated in the solution state by Chatterji and Roy, and was tried on flagellate Prowazekia and *Paramœcium caudatum* which were killed by very small doses.

7. ASHOKA—Saraca Indica.

Vernacular names—Ashok (Hindi, Beng., Mar.), Ashopalave (Guj.).

The bark of this sacred tree has found extensive use in Āyurvedic medicine for hæmorrhoids and dysentery, but besides tannin, no active principle of the nature of alkaloid or essential oil could be extracted out of it.

8. PĪPAL—Ficus Religiosa.

Vernacular names—Pīpal, Pīpar (Hindi, Mar., Guj.), Aswat, Asud (Beng.), Arasa (Tam.), Rai, Raiga (Tel.), Rangi, Basri (Can.). Also known as Ashwattha in Sanskrit.

The bark contains 3.8 per cent tannin, and when dried, leaves 11.7 per cent ash. The wood is supposed to be too sacred by Hindus to be used as fuel.

Palāsh : Butea Frondosa-Roxb.

Vernacular names—Palāsh, Dhāk (Hindi), Palās (Mar.), Khākar (Guj.). Palāsh (Beng.), Puās, Murukkan-maram (Tam.), Modugachettu, Palāsha (Tel.), Muttaga-mara (Can.).

The dry twigs of the plant called samidhās are used to feed Homa or sacred fire. In the *Bhāva-prâkāsh*, the use of the seeds of Palāṣha, as aperient and anthelmintic is noticed; they are directed to be beaten into a paste with honey for administration. The use of the gum as an external

astringent application is mentioned by Chakradatta. Its mixture with other astringents is recommended as a remedy for pterygium and opacities of the cornea. The author of *Makhzan-el-Adwiyā* describes the leaves of Palāsha as very astringent, tonic and aphrodisiac, and says that they are used to disperse boils and pimples and are given internally in flatulent colic, worms and piles. The flowers are astringent, depurative, diuretic and aphrodisiac.

According to Hanbury, Butea gum yields 1.8 per cent of ash and contains 13.5 per cent water. Ether removes from it a small quantity of pyrocatechin. Boiling alcohol dissolves it to the extent of 46 per cent, the solution, which is but little coloured, produces an abundant greyish green precipitate with ferric chloride, and a white one with lead acetate. It may be hence inferred that a tannic acid, probably kino-tannic acid, constitutes about half of the weight of the drug, the remainder being a soluble mucilaginous substance. Buteakino submitted to dry distillation yields pyrocatechin. According to Eissfeldt, it does not contain pyrocatechin but yields it on dry distillation......

...The oil of the seeds is yellow, specific gravity 0.917, it is nearly tasteless and solidifies at 10° (*Lepine*). Brannt gives 0.927 as the specific

gravity. The seeds have been examined by Waeb (*Pharm. Zeitschr. für Russland*, 1886). The results the analysis are as follows, the alkaloids and glucosides were not found :

Moisture	6.62
Ash	5.14
Fat	18.20
Wax soluble in ether	0.25
Albuminoids soluble in water ..	9.12
Albuminoids soluble in soda ..	1.95
Albuminoids insoluble in water and soda	8.49
Substances apparently nitrogenated, soluble in alcohol	0.82
Mucilage	2.28
Glucose	6.87
Organic acids	4.00
Other substances soluble in water	2.16
Metarabic acid and phlobaphene	10.19
Cellulose	3.80
Other insoluble substances ..	22.20

(Dymock, 1890, i, pp. 454-458, Kirtikar Basu, page 440).

The wood as such has not been examin But it is very convenient as a fuel because

plinters retain glow for a pretty long period, he wood itself being consumed only slowly. It is robably due to the fatty constituents oozing out n minute traces in the wood during combustion.

Chandan : Santalum Album, Linn

Vernacular names—Chandan, Safed Chandan (Hindi); Sandanak Kattai (Tam.); Gandhapu-chekka (Tel.); Chandana-mutti (Mal.); Gandhada-chekke (Can.), Chandon, Sada Chandon (Beng.); Chandana, Sukhada (Guj.), Chandana, Gandha-che-khor (Mar.).

Sanskrit medical writers describe sandalwood s bitter, cooling, astringent and useful in bilious ever and heat of body; a paste of wood is directed be applied externally to inflammatory affection f the stem and is a domestic remedy for all kinds f pains and aches. Amongst Hindus, the wood is sed for burning in the pyre (*chitā*). Parsis also se it at their funeral ceremony. As an external pplication, a paste made with rose water and amphor or with sarcocolla and white egg (as escribed by the author of *Makhzan*) may be pplied to relieve headache, or inflammatory swelling. Ainslié states that in Southern India, sandalwood given with milk is regarded as a valuable emedy in gonorrhœa. In the Konkan, sandalwood il with cardamoms and 'Banslochana' (a siliceous

deposit in bamboo) is given in gonorrhœa an mixed with lime juice and camphor it is used a cooling application to eruptions.

Sandalwood was known to Greeks from th time of Alexander. Arrian mentions ξυλασαγαλι among the Indian imports into Oman in the Persi Gulf. Constantinus Africanus, a physician of th school of Salerno, appears to have been the fir to use it medicinally in Europe. Dr. E. Ro found its sedative influence on circulation. remittent fevers in which it was administered, acted as a diaphoretic, diminishing at the same tin the rapidity rather the violence of the heart's actio Dr. Henderson of Glasgow, and in France D Panas, Gubler, and Simmonet have recommend the use of oil in gonorrhœa.

Chemical composition. The wood treated boiling alcohol yields about 7 per cent of a blac extract from which a tannate is precipitated alcoholic solution of lead acetate. Decomposed sulphuretted hydrogen, the tannate yields a tan acid having but little colour and striking a green hue with ferric salt. The extract also contains dark resin. The most interesting constituent the sandalwood is the fragrant essential oil. is a yellowish, remarkably thick liquid havin

high specific gravity (more than 0.960) and is a mixture of hydrocarbons and oxygenated oils boiling at a very high temperature. The specific gravity of a pure sample of oil distilled at Hunsur from the roots was 0.9745 at 15.5°C. M. Chapoteaut (*Bull. Soc. Chim.* 34, 303) has shown that it is composed of two oils, one boiling at 310°C and the composition of the boiling oil at 300°C is $C_{15}H_{24}O$ and the oil boiling at 310°C $C_{15}H_{26}O$. This chemist has been able to obtain with the latter oil a series of ethers under the influence of different acids he brought to act upon it, and has announced the important fact that the oil $C_{15}H_{26}O$ is an alcohol, the aldehyde of which is the oil $C_{15}H_{24}O$. Phosphoric anhydride absorbs water from both, converting them to hydrocarbons $C_{15}H_{22}$ and $C_{15}H_{24}$ respectively. Five per cent oil is obtainable from the sandalwood, though by the Indian process the extraction only yields 2.5 per cent. (Dymock, 1893, iii, 232-238).

Kirtikar and Basu state that the wood yields an essential oil, the amount of which on the average varies from 3 to 6 per cent. It has been observed that the wood growing on hard rocky soil is richer in oil than those growing on comparatively fertile soil (Puran Singh).

The constants of the oil made by mixing the products obtained in the distillations are as follows:

Specific gravity at 26°C	0.9765
Optical rotation	—15.6° to—1(
Saponification number before acetylation	9.72
Saponification number after acetylation	21.13
Santalol content	99.4

Chopra states (p. 243) that "the oil consists in the main of alcohols and their corresponding aldehydes. A body or mixture of isomers known as santalol is the principal constituent of the oil occurring therein to the extent of 90 per cent or more. It is a mixture of two isomers, known as α-santalol and β-santalol. The rest is composed of aldehydes and ketones, e.g., isovaleric aldehyde, santenone, santalone etc."

Deodar : Cedrus Libani

The Sanskrit names of this tree, as Deva-dāru, Sura-dāru, Sura-druma and others mean the tree of gods. It yields auspicious wood which impregnated with oil is used as a carminative, diaphoretic and diuretic by the Hindu physicians

fever, flatulence, inflammation, dropsy and urinary diseases. The wood is also ground with water to a paste and applied to relieve headache. Stewart observed, that in Kāngrā, the wood is pounded with water on a stone and the paste applied to temples to relieve headache. The wood is bitter, useful in fever, costiveness, piles and pulmonary complaints (S. Arjun). A tar made by destructive distillation of wood is a favourite remedy for skin diseases in India.

The wood sold is of a light yellowish brown colour, very heavy and in thin sections, translucent, owing to the large proportions of turpentine contained in it. It has an agreeable terebinthinate odour.

Chemical composition. The following description has been given by Dymock:

An alcoholic extract of the wood was spontaneously evaporated to dryness by exposure to air and the extract agitated with petroleum ether, and the insoluble residue treated with caustic soda and agitated with ether. The petroleum ether extracts on spontaneous evaporation left a transparent pale yellow varnish like residue, with a very fragrant terebinthinate odour which became hard on exposure in thin layers, but preserved a perfect transparency.

This extract was treated with aqueous caustic pot and agitated with ether. The mixture after stand separated into three layers. The lowest strat was of a reddish yellow colour, the middle dark in colour, and the small amount which floated abo the ether of a light yellow colour. The ethere layer on spontaneous evaporation left a mass fragrant odour, which on microscopic examinati consisted of interlaced needles and narrow plates On ignition, an alkaline ash was left. In sulphur acid, it dissolved with yellow colour, no chan being induced by the addition of nitric acid to solution or hydrochloric acid and phenol. In ord to obtain resin in free state, an ethereal solution potash salt was agitated with dilute sulphuric acid On spontaneous evaporation of ether, the acid left as a transparent varnish.

The middle layer mentioned above appeared consist of a concentrated solution of the pot salt of the resin acid, the potash salt not being readily soluble in ether. The aqueous stratum treated with sulphuric acid and agitated with eth the ethereal extract was yellow and had a slig odour, not unlike that of valeric acid.

That portion of the original alcoholic ext insoluble in petroleum ether, was now agit

with ether, and aqueous potash. The ether left on spontaneous evaporation, a transparent yellow extract insoluble in water; soluble in alcohol with neutral reaction and possessing a marked bitter taste. Sulphuric acid coloured the extract a lustre red. The potash solution was mixed with sulphuric acid and agitated with ether; during agitation, dark reddish flocks separated which were insoluble in ether, even after prolonged agitation. The ethereal solution left a yellow transparent residue. In alcohol, the extract was soluble with bitter taste and acid reaction. In concentrated sulphuric acid it dissolved with a dark red colour, the addition of concentrated hydrochloric acid afforded, a colour of crushed straw berries which became reddish violet on the addition of phenol. In aqueous potash, the extract dissolved with a bright yellow colouration. Ferric chloride added to an alcoholic solution gave a dirty brown colouration. The flocks insoluble in ether were of a reddish brown colour, brittle when dry, without bitterness and affording similar reactions with sulphuric and hydrochloric acids, phenol, ferric chloride and caustic soda to the resin soluble in ether. (Dymock, 1893, iii, 380-382).

Oil from Deodar, and other cedar wood oils

including pinewood oils contain a number of hydro-carbons. α-Pinene is an usual constituent of such oils, derived from leaves, barks or woods. It is also principally obtained in the distillate from the oleo-resins of the several species of *Pinus*. β-Pinene is also present in turpentine oils, along with limonene, dipentene and allied products. The oils of cedar wood contain cedrol, $C_{15}H_{26}O$, (M.P. 86°, B.P. 292°C.).

Agar : Aquilaria Malaccensis, *Lamk*
or *A. Agallocha*, *Roxb.*

This wood, which in Indian vernaculars is known as *agar* or *agaru*, has been used as perfume and medicine since very old days. In Sanskrit medical works, it has been described as hot, light and cholagogue, removing diseases of the ear, nose and eyes. In native practice, *agar* is used as deobstruent, stimulant, carminative and tonic. Suśruta directs Agaru, Guggula, Sarjarasa, Vacha, white mustard, Neem leaves and salt to be made into paste with ghee to form an anodyne fumigation for surgical wounds.

The wood occurs in irregular pieces, which vary in colour from grey to dark brown, according to the amount of resin which they contain; both li

coloured and dark pieces are marked with longitudinal veins of a darker colour. The taste is bitter and aromatic and when burnt, the wood diffuses an agreeable odour.

J. G. Prebble found on examination that the true *agars* vary considerably in the amount of resin they contain; old and decayed samples consist largely of resins. A good specimen yielded to Hanbury [illegible]8 per cent of matter soluble in rectified spirit. Compact and not apparently very resinous samples of Gaguli and Marwadi Agar treated successively with petroleum ether, ether and alcohol gave the following figures on analysis :

	Volatile oil	Resin soluble in ether	Resin soluble in alcohol, insoluble in ether
Gaguli ..	½ %	13.8 %	9.4 %
Marwadi ..	1.5 %	11.6 %	9.0 %

The volatile oil is of a yellow colour and possesses the characteristic odour of the woods. It gives reddish brown coloration with sulphuric acid. The ether resin is soluble in aqueous solution of potash with a reddish brown colour, from which

the resin is precipitated by acids. (Dymock, 18
iii, 217-232).

Taggar Wood, or *Asarum Europæum, Linn.*

According to J. G. Pebble, "Taggar wood is heavy dark coloured oily and resinous wood, t botanical origin of which is unknown, import into Bombay from Zanzibar. It sinks in water an its aqueous infusion has a yellow colour wit greenish fluorescence."

According to Dr. Royle's Catalogue, Tagg wood was sent from Delhi to the great exhibitio of 1851. Twenty pounds of the ground woo submitted to distillation with water during thr consecutive days, yielded six fluid ounces, equiv lent to 2 per cent of a yellowish oil which is quick changed to a reddish brown colour. The oil neutral of specific gravity 0.9546, bitter, and w an odour resembling with but distinct from sand wood oil. It dissolves in all proportions of al cohol, ether, chloroform, benzene and petroleu ether. It dissolves iodine without violent reactio and yields no characteristic reaction with sulphur acid, being only darkened in colour. Exposed air in a thin layer, it acquires a crimson colo At a low temperature, by keeping in ice, the

remains clear and free from any deposit, but becomes very thick and viscid and develops a very strong greenish fluorescence which vanishes completely or nearly so at a higher temperature, 85° F.

The finely powdered wood, treated successively with petroleum ether, ether and alcohol yielded to the petroleum ether 8.57 per cent of a mixture of volatile oil and resin which deposited on the sides of the evaporating dish a few small tubular crystals. On drying at 110°C, this mixture of oil and resin lost volatile oil equivalent to 5.7 per cent. The ether extracted a resin, 6.4 per cent, soluble in aqueous solution of potash with a deep reddish brown colour, and greenish fluorescence in solutions of ammonia and sodium carbonate. The resin is precipitated from these solutions by acids. Strong sulphuric acid dissolves the resin with red colour, from which it is precipitated by water in yellowish brown flocks. It is readily soluble in glacial acetic acid, but no crystals were obtained on the spontaneous evaporation. It is soluble in benzene, and petroleum ether, and in boiling alum solution. The resin probably contains an anthraquinone derivative allied to emodin and chrysophanic acid. (Dymock, 1893, iii, 223-224).

A glucoside appears to be present along with

the essential oil. (See *Ber.*, 1888, 1057; also *Pharm. Chim.*, 1911, 399).

Tagar : Valeriana Wallichii, DC.

Vernacular names—Tagar (Hindi, Beng., Mar.), Tag ganthoda (Guj.), Nandibattal (Can.), Mushk-i-w Bala (Punjabi), Pampe (Bhutan).

The other names for it are Nanyavarta, Nandini, Varhi Nahushakhya, Pinditagara, Nahani, Shumeo, Asarún.

In Sanskrit medical works, it is described a sweet emollient, pungent, hot and light; a remed for suppression of urine, poisons, epilepsy, swoon and headache. Besides its medicinal uses, it is a ingredient in perfume powders, in the same manne as Jatāmānsi.

The rhizome of the wood is crooked, abo two inches long, and is very hard and toug and the fractured surface greenish brown. T odour is like Valerian, but much more powe ful.

The analysis of rootstock has been made b J. Lindenberg and the results compared with fresh analysis of the roots of valeriana Officinali made by the same chemist (*Pharm. Zeits. f Russland*, 1886). The following table shows t results :

	V. Wallich.	V. Officin.
Ash	4.04%	4.31%
Moisture	10.46	11.57
Fat and resin soluble in petroleum benzine	0.56	0.36
Volatile oil and valeric acid soluble in benzine	1.005	0.90
Volatile acid soluble in ether	0.335	0.31
Resin and wax soluble in ether	0.56	0.85
Resin soluble in alcohol	1.05	0.975
Tannin	3.13	1.64
Citric, tartaric and other acids	0.335	0.565
Glucose	6.03	5.32
Other substances soluble in water but insoluble in alcohol	14.96	14.39
Mucilage and albumin soluble in water	4.16	2.97
Albuminoids extracted by soda	9.72	7.83
Metarabic acid, phlobaphene, and albuminoids	19.10	16.70
Starch	14.05	12.87
Cellulose	10.36	11.65
Lignin and other compounds	10.015	16.80

(Dymock, 1891, ii, 238, 413).

Also see Chopra and Ghosh, *Indian J. Med. Res.* 13, Jan. 1926; Bullock, *Pharm. Journal*, 115, 122 (1925); 117, 152 (1926).

During antiquity, valerian was known as *Phu*, as described in the writings of Dioscorides and Pliny. During the Middle Ages as is apparent from the works of Turner (1568) and Langham (1633), the odour of valerian must have been a favourite for it was used for perfuming rooms, clothing and linen. Valerianic acid was isolated by Trommsdorff from the aqueous distillate of the root in 1830.

B—Camphor

Kapūr : Cinnamomum Camphora

Vernacular names—Kapūr or Kāfūr (Hindi), Ka (Sans.), Karppūram, Shūdan (Tam.), Karpūram (Mal.), Karpūra (Can.), Kāpūr, Kāphūr (Ben Kāpūr (Mar., Guj.).

There are a number of camphor bearing pla found in India. For example, Blumea balsamifera B. lacera, B. densiflora, B. malcomii, B. grandis an many others grow in the Himālayas from Nep to Sikkim and also in the Western part of th Deccan plateau. Densiflora and balsamifera a very prominent varieties amongst these. Bo these are found in plenty in Āssām and Burm Not only the species of Blumea, there are ma other plants in this country which smell strong of camphor. The common aquatic weed of t plains of Bengal, *Limnophila gratioloides*, the Karp of the Bengalees is an example (Chopra, p. 114).

The so-called Indian camphor of trade is rea Chinese camphor refined in India. Only a sma amount of Blumea camphor is truly Indian. T production of camphor in China having come to decline, the Japanese are now the only produc with Formosa as the chief centre of their wo

All parts of the camphor tree yield on distillation a semi-solid oil from which camphor can be separated mechanically. The oil from the wood and the root has the highest value as it not only contains camphor but a valuable substance 'safrole' also. Though most of the camphor is used in celluloid industry, 15 per cent of it goes to disinfecting and deodorising purposes and about 13 per cent to medicinal purposes.

The Japanese camphor tree yields 2.2 to 5.5 per cent of camphor oil (i.e., the residue left after camphor sublimes over), the greatest yield being from stumps and roots. Indian camphor trees give the following figures for camphor and camphor oil content:

	Camphor %	Camphor oil %
Nilgiri	0.1-0.7	0.9-0.3
Madras	1.99	0.63
Burma	1.03	0.48
Cochin	2.01	0.32
Dehradun	0.38	3.66

Camphor is a hygroscopic substance, the crude China variety supplied in white or brown grains is more or less moist. The crude Japanese variety consisting of grains adhering in masses is dry and has sometimes a pinkish tinge. The Bombay refined

camphor is in porous cakes and contains m
water.

The constituents of camphor oil are pin
phellandrene, cineol, dipentene, camphor, terpin
safrol, eugenol and sesquiterpene which sublim
different temperatures between 160° and 27
(Dymock, 1893, iii, 200-203).

In the fumigating process, with which we
concerned here, camphor is used for initiating fi
It readily catches fire and burns with a smoky flam
During the course of burning, a portion of it
volatilised out also almost undecomposed, a
spreads fine aroma.

C—Milk and Butter

Ghee or *Clarified Butter*

The composition of cow's and buffalo's m
according to Godbole and Sadgopāl is as follow

		Cow's	Buffalo's
Total solids	..	12.9–14.5	18.0–22.5
Albuminoids	..	3.4–4.0	5.3–6.15
Fat	..	3.0–3.85	6.5–8.75
Milk sugar	..	4.5–5.2	5.0–5.4
Ash	..	0.45–0.65	0.7–0.95
Density	..	1.026–1.035	1.038–1.04

The composition of healthy cow's milk as gi

A. W. Blyth (*Foods : Their Composition and* *nalysis*, 1909, p. 204) is as follows :

			Parts per cent by weight	
ilk fat :	Butyrin	..	0.15	3.90
	Caproin	..	0.14	
	Caprylin	..	0.02	
	Caprin	..	0.07	
	Laurin	..	0.29	
	Myristicin	..	0.79	
	Palmitin	..	1.00	
	Stearin	..	0.07	
	Olein	..	1.37	
Casein	..	..	..	3.00
Albumin	..	..	..	0.40
Milk sugar	..	..	..	4.75
Ash	..	..	..	0.75
Water	..	..	..	87.2

The ash of the milk has the following compo-
ion :

Potassium oxide	..	18.82
Sodium oxide	..	11.58
Calcium oxide	..	22.97
Ferric oxide	..	0.6
Chlorine	..	16.23
Magnesium oxide	..	3.31
Phosphorous pentoxide	..	27.03

The general composition of butter-fat as given Blyth (*ibid.*, p. 272) is as follows :

			Glycerides equal to fatty acids		
Olein	...	42.21	=	Oleic acid ...	40.40
Stearin and Palmitin	...	50.00	=	Stearic and Palmitic acid ...	47.50

5

Butyrin	...	4.67 =	Butyric acid	...	3.
Caproin	...	3.02 =	Caproic acid	...	2.
Caprylin and rutin	...	0.10 =	Caprylic and rutic acids	...	0.

Bell obtained the following products saponifying 100 parts of butter fat:

Butyric acid	..	..	..	..	6.
Caproic, caprylic and capric acids			..	..	2.
Myristic. palmitic and stearic acids			..	..	49.
Oleic acid	..	..	..	..	36.
Glycerol ..	..	..	..	..	12.

Browne (*J. Amer. Chem. Soc.*, 1899, 21, 8 has given the detailed analysis as follows:

Acid		Percentage of acid	Percentage of triglyceric acid
Dihydroxy stearic	..	1.00	1.04
Oleic	..	32.5	33.95
Stearic	..	1.83	1.91
Palmitic	..	38.61	40.51
Myristic	..	9.89	10.44
Lauric	..	2.57	2.73
Capric	..	0.32	0.34
Caprylic	..	0.49	0.53
Caproic	..	2.09	2.32
Butyric	..	5.45	6.23
		94.75	100.00

According to Duclaux (*Compt. rend.* 1886, 1022), butter fat contains 2 to 2.26 per cent capric and from 3.38 to 3.65 per cent of bu

ds. Lewkowitsch finds only 0.49 per cent of ric acid in the insoluble fatty acid of butter

In the following table, are given the results he analysis of cow-butterfat and buffalo-butterfat given by Godbole and Sadgopāl. For comison, the values given by Holde, Bleyberg Grun regarding the cow-butterfat are also wn:

nstituents		Cow-butterfat (Holde-Bleyberg)	Cow-butter-fat	Buffalo butterfat
ic acid	..	1.1–5.9%	10%	12.%
itic acid	..	11.8–17.5	26	31
c acid	..	24.47	34.5	30
leic acid	..	..	5.0	4
ric acid	..	2.9–4.5	4	4
aic acid	..	1.3–2.4	2	2
ylic acid	..	1–1.9	0.9	0.9
ic acid	..	1–1.5	2	2
ic acid	..	3.6–6.4	4.5	4
stic acid	..	10.4–20.1	10	9

D—Grains and Cereals

Rice

Rice is obtained from the Oryza sativa and the n is popularly applied only to the seed denuded usk and inner cuticle, the composition of which s follows:

Water	14.41	per cent
Nitrogenous substance	6.94	
Fat	0.51	
Starch	77.61	
Woody fibre	0.08	
Ash	0.45	

The oil which is obtained from the rice em has a density of 0.924 at 15° and at 5°C bec thick and buttery. It contains much olein an albuminous substance. (A. Pavesi and E. Rot *Gaz. Chimica Italiana*, IV, 192-195).

The composition of the ash of rice is as follo

Potash	21.73	per cent
Soda	5.50	
Lime	3.24	
Magnesia	11.20	
Ferric oxide	1.23	
Phosphoric acid ..	53.68	
Sulphuric acid ..	0.62	
Silica	2.70	
Chlorine	0.10	

(A. W. Blyth and M. W. Blyth, *Foods*, 1909,

Barley and Malt

A number of species of barley are culti which all of them may be considered to be bel ing to the varieties of the following specie hordenum: H. hexastichon, H. vulgare, H. criton. The following is the analysis of ba

al, that is, the grain being ground whole:

Water	15.06	per cent
Nitrogenous substance	11.75	
Fat	1.71	
Carbohydrates ..	70.9	
Woody fibre	0.11	
Ash	0.47	

The nitrogenous substances are hordein, glu-n, leucosin, globulin and proteoses. The stituents of the barley ash are as follows:

h	20.15	per cent	Phosphoric acid	34.87	per cent
	2.53		Sulphuric acid	1.39	
	2.60		Silica	27.64	
nesia	8.62		Chlorine	0.93	
c oxide	0.97				

(A. W. Blyth, *Foods*, 1909, 171).

The compositions of air dried malt and air d barley are as follows:

	Barley	Malt
extrin	5.6	8.0
tarch	67	58.1
ugar	0.0	0.5
ellulose	9.6	14.4
lbuminous substances	12.1	13.6
atty substances ..	2.6	2.2
sh etc.	3.1	3.2
	100.00	100.0

(A. W. Blyth, *Foods*, 1909, 410).

Wheat or Godhūm, Gaihūn

TRITICUM SATIVUM, LAM.

The different varieties of wheat are Tri sativum, T. vulare, T. hybernum and others. mean composition of wheat according to K is as follows:

Water	13.56	per cent
Nitrogenous substances ..	12.42	
Fat	1.70	
Sugar	1.44	
Gum and dextrin	2.38	
Starch	64.07	
Fibre	2.62	
Ash	1.79	

Some of the Russian wheat contain nitroge substances even to an extent of 21.56 per cent. ash of entire wheat has the following composi

Potash	30
Soda	2
Lime	3
Magnesia	12
Phosphoric acid	48
Others	5

Others include traces of ferric silica, chlorine and sulphat

According to Peligot, the composition of flour is as follows:

Water	14.0
Fat	1.2
Water insoluble nitrogenous matter	12.8

ater soluble nitrogenous (albumen) matter	1.8
luble non-nitrogenous matter - dextrin	7.2
arch	59.7
llulose	1.7
h	1.6

(A. W. Blyth, *Foods*, 146).

Other minor cereals

1. URD—Phaseolus Radiatus.

rnacular names—Māsh (Sans.), Urd or Urid (Hindi), Māshkalai (Beng.), Udid (Bom.), Patchaypyre (Mad.).

The analysis as given by A. H. Church in his *ood Grains of India* (1886, p. 151) is as follows:

In 100 parts with husk

Water	10.1
Albuminoids	22.7
Starch	55.8
Oil	2.2
Fibre	4.8
Ash	4.4

(Also *J. Amer. Chem. Soc.* 1897, 509).

2. MUNG—Phaseolus Mungo.

ernacular names—Mudga (Sans.), Mūng (Hindi, Beng., Mar.), Puchapayaru (Mad.).

The following are the figures of analysis accord-

ing to Church (*ibid.*) for green as well as yel
seeds :

In 100 parts with husk

	Green	Yellow
Water	10.8	11.4
Albuminoids ..	22.2	23.8
Starch	54.1	54.8
Oil	2.7	2.2
Fibre	5.8	4.2
Ash	4.4	3.8

(Also see *Compt. rend.* 1930, 934, and *Arch. Pharm.* 19
67).

3. CHANĀ—Cicer Arietinum. (The Ch
Pea).

Vernacular names—Chanā (Hindi), Chholā (Beng.), Kac
(Madras).

Church has given the following figures for an
lysis (p. 128) of the pea with husk and witho
husk :

	Without husk	With husk
Water	11.5 per cent	11.2 per cent
Albuminoids ..	21.7	19.5
Starch	59.0	53.8
Oil	4.2	4.6
Fibre	1.0	7.8
Ash	2.6	3.1

Oxalic, acetic, malic and some other acids ha

o been reported to be present in it. 100 g. ds contain 0.009 mg. arsenic also.

(Also see *Compt. rend.* 1912, 893; *Pharm. Ind.* l. I, 488).

Til: Sesamum Indicum-DC.

nacular names—Til (Hindi, Beng.); Ellu (Tamil); Nuvvu-lu (Tel.); Kārellu (Mal.); Yellu (Can.); Mothetil (Mar.); Tal (Guj.).

On certain festivals in a Hindu family, six acts performed with til seeds: these are *tilodvarti* thing in water containing the seeds), *tilsnāyi* ointing the body with pounded seeds); *tilhomi* king burnt offerings of the seeds); *tilprada* ering the seeds to the dead); *tilbhuj* (eating the ds); and *tilvapi* (throwing out the seeds).

Sesamum is considered fattening, emollient, laxative. In decoction, it is said to be em-nagogue; the same preparation sweetened with ar is prescribed in cough; a compound decoc-n with linseed is used as aphrodisiac; a plaster de of the ground seeds is applied to the burns, lds etc.; a lotion made from the leaves is used hair wash, and is supposed to promote the wth of the hair and make it black; a decoction the root is said to have the same properties.

Chemical composition :

The following table shows the relative composition of the brown or Levantine and yellowish Indian seeds :

	Levantine	Indian
Oil	55.63 %	50.84 %
Organic matter ..	30.95	35.25
Ash	7.52	6.85
Water	3.90	7.06

the albuminoids being equal to 21.42 and 2[illegible] per cent respectively in the two varieties.

In the first pressing, about 36 per cent is obtained while in the second about 11 per c[illegible] The oil-cake has the following composition:

Water	8.25
Fat	7.63
Non-nitrogenous matter	40.90
Albuminoids containing 5.25 % nitrogen ..	32.82
Ash	10.40 (Brannt)

The oil is a mixture of olein, stearin and other compounds of glycerin with acids of the series. A specimen of sesame oil examined, contained 76.0 per cent of olein, inasmuch must be supposed to be present in the form of olein. In commercial oils, the amount of olein is certainly not constant.

In the solid part of the oil, was found stearic cid mixed with one or more of the allied homo- gous acids as palmitic and myristic. The isolated cids melted at 52.5 to 53°, 62° to 63° and 69.2°C hich correspond to myristic, palmitic and stearic cids.

Sesame oil contains an extremely small quantity f a substance, perhaps, resinoid, which has not yet een isolated. It may be obtained in solution by epeatedly shaking five volumes of the oil with ne of glacial acetic acid. This substance has been nalysed by Tocher.

Kirtikar and Basu give the following descrip- on of the sesame oil : Regarding the amount of oil the seed, Leather found that the variation is from 8 to 52 per cent, though some specimens contained s much as 56 per cent and some as little as 45 per ent. These differences appear to be independent f variety, province or climate. From 42 to 48 er cent oil may be obtained by expression. The eeds also contain about 3 per cent of the nitrogen nd the cake is excellent cattle food. If made rom unsound seed, the cake may be used as a anure.

Sesame oil has been frequently examined by hemists and the following average constants are

quoted: sp. gravity at 15° 0.923 to 0.926; solidifying point −5°; saponification value 187.6 to 194.6; iodine value 103 to 115, Reichert-Meissl value 1.2; Mauméne test 63° to 5°; butyro-refractometer at 25°, 68.0; insoluble fatty acids and unsaponifiable, 95.7; melting point 25° to 30°; neutralisation value 196 to 201; mean molecular weight 286.

Sesame oil contains, according to Farnsteiner, 12.1 to 14.1 per cent of solid acids, and according to Lane 78.1 per cent of liquid fatty acids. These consist of oleic and linoleic acids. Sesame oil is dextro-rotatory, a property which may be used as an additional means of identifying the oil. The Indian oil has a lower rotation than the African. The amount of unsaponifiable matter in sesame oil varies from 0.95 to 1.32 per cent and contains phytosterol, sesamin and a so-called red oil. The phytosterol recrystallised from alcohol melts at 139°. In 18[illegible] Tocher extracted from the oil, by means of glacial acetic acid, a recrystallised substance sesamin. This melts at 118° and assumes a green and then bright red colour with nitro-sulphuric acid.

E—Odoriferous Herbs

Kapur Kachri : Hedychium Spicatum, Ham.

rnacular names—Kapūr Kachrī, Kachūr-kach; Kachrī (Hindi); Kāpūr Kachari (Mar., Guj.); Shimai-kich-chilik-Kishangu (Tam.).

In Himalayas, it is known as Sheduri, and the aves are made into mats which are used for sleep-g purposes by the hill people. The aromatic ot stocks are used as perfume along with Henna awsonia abba) in preparing the cloth known in e N. W. Provinces as Malagiri (Watt). The ced and dried root is an article of considerable portance in Indian trade as it is a principal ingre-nt in the three kinds of Abir or scented powder ed by Hindus in worship and as a perfume.

Two kinds of Kapur Kachri are found in rket, viz., Chinese and Indian. Indian Kapur chri occurs in slices, mostly circular with sections sloping directions. Slices are white and starchy, d when fresh, they exhibit a faint line dividing cortical from the central portion, the edges of ch slice are covered by a rough reddish brown rk marked with numerous scars and circular gs; here and there, the rootlets remain attached; odour is like that of orris root, but more power-

ful and strongly camphoraceous, the taste pung bitter and aromatic. The Chinese variety is a li larger than the Indian, whiter and less punge the bark is smoother and of a lighter colour.

The dried tubers have been examined by J. Thresh (*Pharm. Journ.* (3) xv, 361). The appro- mate results are given below:

Soluble in petroleum ether—		
Ethyl methylpara coumarate ..	3.0	5.
Fixed oil and odorous body ..	2.9	
Soluble in alcohol—		
Indefinite substance precipitated by tannin, acid resin etc. ..	2.7	
Soluble in water—		
Glucoside or saccharine matter ..	1.0	
Mucilage	2.8	
Albuminoids and organic acids ..	1.9	
Starch	52.3	
Moisture	13.6	
Ash	4.6	
Cellulose etc.	15.2	
	100.0	

The odorous principle was extracted petroleum ether and then allowed to evapo

wly whence an abundant crop of large crystals
s obtained, together with a pale yellowish brown
y liquid. These crystals after washing with cold
roleum were submitted to a series of recrystalli-
ons in order to remove traces of odorous matter.
ey were finally obtained quite colourless and
nd to possess the following properties : soluble
petroleum ether, ether, alcohol, chloroform, and
zene ; insoluble in dilute solutions of potash,
a or ammonia. Sulphuric acid dissolved it in
d without production of colour, but if heated the
ition became purple red. The alcoholic solu-
was neutral in reaction ; not coloured by ferric
oride or precipitated by basic lead acetate. It did
reduce silver salts. The melting point was
nd to be 120°—121°F. (49°C). The empirical
nula $C_{12}H_{14}O_3$.

The uncrystallisable portion of the petroleum
er residue was found to consist of the odorous
iciple, a fixed oil and a very considerable portion
ethyl methyl para-coumarate, the latter being
loubtedly prevented from crystallising by the
sence of the former. Upon saponification of the
ture with alcoholic potash two crystalline acids
re obtained, the methyl para coumaric and
ther apparently a fatty acid. This latter was

totally insoluble in boiling water but crystall from alcohol. The quantity obtained did enable the author to identify it with certainty minute quantity of the oily liquid above menti dropped upon the clothes rendered them hi odorous for a considerable length of time, exposed, caused a large room to be pervaded an odour resembling that of hyacinths.—(Dy 1893, iii, 417-420).

Gugal : Boswellia Serrata, Roxb.

Vernacular names—Salai, Gugel (Hindi) ; Gugar (Guj.).

Probably the true Sanskrit name fof it is Sa from which the Hindi word Salai has been der The exudation from the tree is called the Sa drava or Sihla and Guggula. Dr. Hamilton cribes it as of the consistence of turpentine wh flows from the tree ; in the dry state, it is Sukha-biroza. Sanskrit writers describe Gu as moist, viscid, fragrant and of a golden c when freshly exuded. It is said to be demul aperient, alterative and a purifier of the blood.

The fresh exudation has the colour and co tence of Canada Balsam ; it hardens very sl retaining its golden colour and transparency.

our is that of olibanum but fainter and more ebinthinate; cold water converts it into a soft itish pulp which when rubbed in a mortar, forms emulsion. Spirit also makes it white and opaque dissolving the resin. In short, it resembles banum but does not harden like it. It burns idily and diffuses an agreeable odour. (Dymock, 90, i, 302).

Kirtikar and Basu give the following extract m the Annual Report of the Board of Scientific vice for India, 1914-1915 (pp. 128-129): "The swellia serrata (salai) gum resin enquiry is now roaching a definite conclusion. During the r, samples of the oil and resin, products of steam illation were forwarded for valuation to the perial Institute, London. The report on these been received and is to the effect that the oil sely resembles American turpentine oil except regards smell and is of excellent quality and will dily command a market, the resin on the other d is of a poor quality, the defects being low onification value and bad odour."

Another substance known as Guggul is *Balsodendron mukul*, which is an oleo-gum resin. It is n used as an adulterant in Balsamodendron rrha with which it resembles very closely.

Myrrha contains 30 to 60 per cent gum, 27 t[o] per cent of resin, 2.5 to 10 per cent of an esse[ntial] oil and some bitter substances. The essential contains cumic aldehyde, phenols like eugenol meta-cresol, pinene, dipentene and limon[ene]. *Balsamodendron mukul* probably also possesses same composition, differing only in some of details. (Finnemore, *The Essential Oils*, 1926).

Nagar-Motha : *Cyperus Scariosus*, R. *Br.*

Vernacular names—Nāgar-mothā (Hind., Guj.) ; Nāgar-M[othā] (Beng.) Lavala, Nagarmotha (Mar.), Muttah-kā-ch[...] Kola-tunga-muste (Tel.), Konnari (Can.), Nagar-mu[staka] (Sans.).

This plant produces the aromatic tubers w[hich] have long been in use in Hindu medicine [and] perfumery under the Sanskrit name of Nā[gar-]mustaka ; they are considered to have the s[ame] medicinal properties as those of *C. ~~rotundus~~*. In Concan, Nagar Motha, Solanum indicum, Ti[nos]pora cordifolia, ginger and emblic myrobalans each 2 tolas, are powdered and divided into 5 p[arts] and one part taken daily in decoction with a [little] honey and long pepper as a febrifuge. Si[milar] preparations are mentioned in *Vanaushidhi Prak[ash]*.

The outermost layer of the cortical porti[on]

mposed of large bundles of reddish brown stony ls, separated from one another by interspaces; thin it are from 6 to 8 rows of very thick walled pty cells; next a tissue of thick walled cells, st of the full of large starch granules, but some ntaining essential oil and probably resinous tter. The central portion of the tuber is separa- l from the cortical by a single row of small low stone cells; it is composed of thick walled ls full of starch like those in the cortical portion, t differs from it inasmuch as many of the cells ntain red colouring matter. Large vascular ndles abound in the root, some of them are rounded by a layer of stony cells.—(Dymock, 93, iii, 554-55).

Roots are used medicinally as a diaphoretic and ringent. Stimulant and diuretic properties are attributed to them. They are further described vermifuge. In native practice, they are held great esteem as a cure for disorders of the mach and irritation of the bowels.

(Kirtikar and Basu, p. 1356).

Balchhar : *Nardostachys Jatamansi*, *D.C.*

(N. O. Valerianeæ)

Vernacular names—Chhar, Bālchhar, Jatāmānsī, Billi-(Hindi), Jatāmānsi (Beng., Mar.), Jatāmāshi (Tam.), Jatāmāṁshi (Tel.), Jatāmānshi (Can.), Bhutkesh (H-riya).

This plant, in Sanskrit, Jatamansi, Bhutkeshi, Pisitā, Tapasvinī and Mishi has from remote period been in use among Hindus perfume and medicine. It is mentioned by Susruta in a prescription for epilepsi, and is prescr by Hindu physicians as a nervine tonic and carmtive, and aromatic adjunct in the preparation medicinal oils and ghritas (butters). In the Niantas, it is described as cold and a remedy leprosy, morbid heat and erysipelas.

Arabic and Persian physicians describe mānsi under the name of "Sumbul-i-Hindi," "In Spike." The author of *Makhzan-el-Adwiya* cribes Jatāmānsi as deobstruent and stimu diuretic and emmenagogue, and recommends various disorders of the digestive and respira organs, and as nervine tonic in hysteria.

Ainslié states that the Vytians in Lower prepare a fragrant and cooling liniment for

ad from this drug and also prescribe it internally a purifier of the blood. Sir W. O. Shaughnessy tes as the result of his experience with Jatāmānsi at it is a perfect representative of valerian. ymock 1891, ii, 233).

The roots are aromatic, and bitter in taste. ey are supposed to possess tonic stimulant and tispasmodic properties and are often employed the treatment of epilepsy, hysteria, and convulsive ections (Watt). Jatāmānsi is also used in the lpitation of heart.* (Thomson in *Watt's Dictionary*).

(Kirtikar and Basu, p. 665).

The drug consists of a short portion of rhizome out as thick as the little finger, of a dark grey our, surmounted by a bundle of reddish brown res, the whole forming an object not unlike the of a sable or martin. The odour of the drug heavy and peculiar, like a mixture of Valerian l. Patchouli, the taste bitter and aromatic.

Kemp (1884) obtained three fluid ounces of the from 56 lbs. of Jatāmānsi and found it to have a lecular rotation of —19.5 in 100 mm., the ecific gravity at 82°F. was 0.9748. One hundred

*Also see Chopra, 586.

pounds of the root submitted to distillation w water by Messrs Kemp and Co. (1890) yielded ounces of a pale yellow oil of valerian like od and a faintly acid distillate. A fine violet or bl colour is produced as with oil of valerian, by mi a drop or two of the oil with about 20 drops carbon disulphide and a drop of strong nitric ac With sulphuric acid, the oil gives a reddish bro coloration. On boiling, the oil acquires a da hue and greenish fluorescence. (J. G. Prebble).

The most important constituent of val root is its volatile oil. Free valerianic acid not exist in the fresh root, but is generated from volatile oil on exposure. Bruylants (1878) stu the oil. The hydrocarbon, $C_{10}H_{16}$ was na borneene by Gerhardt (1841) and valerene Pierlot (1859). The valerol of the latter diff from Gerhardt's valerol, $C_6H_{10}O$, which he belie to become oxidised in contact with air to valeri acid, carbonic acid being given off at the s time. Bruylants explains the generation of val nic acid in old oil of velerian from the decomp tion of C_{10} H_{17} ($C_5H_9O_2$,) which is the valeri ether of borneol; besides this one, it contains corresponding ethers of formic and acetic acids, alcohol borneol $C_{10}H_{18}O$ and its ether $C_{10}H_1$

...rhardt assumed the production of borneol from hydration of borneene.* (Dymock).

Nar-Kachura : *Curcuma Cæsia*, Roxb.

...*rnacular names*—Nar-kachūrā, Kalī Haldī (Hind. and Guj.), kali halad (Mar.), Kali halad, Nilkanth (Beng.), Māna-pasupa (Tel.).

The plant is a native of Bengal and is cultivated ...ere to supply the Indian market. Nar-kachūrā ... considered to have nearly the same properties ... Kachūra ; it is chiefly used as a cosmetic. The ...thor of the *Makhzan* describes it as a kind of ...umbād.

The minute structure of this tuber hardly differs ...m that of the zedoary. The starch contained in ... cells of the parenchyme has been altered by ...at and appears as a finely granular mass nearly ...ing the cell. The resin cells are about as numer-...s as in the zedoary, but the contents are of a ...sky orange colour. The vascular system consists ... scalariform and spiral vessels. As to the ...ug, it consists of small nearly globular central ...bers, from which spring numerous lateral rhi-...mes about the size of ginger. It is of a dark

*Also see *Pharm. Ind.* II, 237; *Schim. Ber.*, 1907, Oct., ... 1926, 75.

grey colour externally and marked with ci
rings. Internally, it is very hard and horny
greyish black colour but when cut in thin
of a greyish orange. The odour and taste
camphoraceous.

The chemical analysis of this curcuma gave
following results :

Essential oil, resin etc.	..	..	4.47
Resins, sugar etc. ..	..	..	1.21
Gum, organic acids	..	..	10.10
Starch	..	..	18.75
Crude fibre	..	..	25.20
Ash	..	..	7.57
Moisture	..	..	9.76
Albuminoids	..	..	22.94
			100.00

(Dymock, 1893, iii, 403. Also, Kirtikar
Basu, pp. 1248 ; Chopra 280).

Curcuma Zedoria, Roxb.

It has been said that curcuma cæsia is si
to curcuma zedoria, which is known as Karc
(Sanskrit) and Kachūra (Hindi and Bengali).
fresh root is considered to be cooling and diu
and purifies blood; checks leucorrhœal
gonorrhœal discharges. The rhizome posse

natic, stimulant and carminative proper-

Zedoary contains according to Bucholz (*Repert. m.* xx., 376) volatile oil, a bitter soft resin, a er extractive matter, gum, starch etc. The oil urbid, yellowish, white and viscid, has a cam-raceous taste and smell, and consists of two one lighter and the other heavier than water. mmsdorff obtained from the root, a substance ch he called zedorin, but did not further ribe it. On approximate analysis, the follow-results were obtained :

Essential oil, resin, curcumin	..	3.79
Resins, sugar	.. .. ..	0.90
Gum and organic acids	.. ..	15.22
Starch	.. .. ..	17.20
Crude fibre	.. .. ..	10.92
Ash	.. .. ..	6.06
Moisture	.. .. ..	10.31
Albuminoids, arabins etc.	..	35.60
		100.00

(Dymock, 1893, iii, 402-3. Also Chopra, 481; *. Jr. Sci.*, 1909, 132; *Schim. Ber.* 1911, April,

Kulanjan : *Alpinia Galanga* (*N. O. Citamin*

Vernacular names—Kulinjana, Dumparastma (Sans.); jan (Hindi); Kulinjan (Beng.); Kosht-kulinjan Pera-rattai (Tam.); Pedda-dumpa-rash-trakam Khusravedurue-kalan (Pers.).

This perennial plant of this country h reputation in the indigenous system of med and is especially favoured in the South has become a household medicine for bron catarrh. The rhizomes are useful in rheum and catarrhal affections. The tubers and seed said to possess carminative properties and are as a fragrant adjunct to complex prescrip Its tincture when injected intravenously produ sharp fall in blood pressure. It has got a ver oil as an important constituent, and there suggestions have been made to use it as a carr tive. The drug has a slight irritant action o mucous membrane of the stomach and this m used in producing a reflex increase in the bron secretion. Yajolu found that administration paste of *A. galanga* in honey lessened the parox of cough in children suffering from whoo cough.

The constituents of Galanga root have

ated by Jahus (Kirtikar and Basu). He found e different compounds, (i) camphoride, (ii) ngin, and (iii) alpinin, but the results have not been confirmed. From the green rhizomes, a yellow oil with a pleasant odour can be obtained distillation. This oil contains 48 per cent hyl cinnamate, and 20 to 30 per cent cineol, phor, and probably d-pinene.

(Chopra, p. 277).

Sugandhabālā : *Pavonia Odorata, Willd.*

acular names—Sugandhabālā (Hindi), Bālā (Beng.), Kalavālā (Mar.), Peramutiver (Tam.), Bālarakkasi-gida (Can.).

This plant is called Bālā and Hrivera in Sanskrit. root is used in Hindu medicine to prepare a r drink known as Shaḍanga Pānīya, which is le by boiling one drachm each of the roots Andropogon muricatus, and Cyperus rotundus pertenuis, Red Sandalwood, the herb of Oldenlia herbacea, the roots of Pavonia odorata, and ginger in two seers of water down to one . It is considered to be cooling and stomachic. Roots are seven to eight inches long, more or twisted, not more than 1/4 inch in diameter he thickest part; giving off numerous thin fibres having a delicate musky odour. Bark is light

brown, nearly smooth; and wood is hard yellowish in colour. The plant has a musky of the roots; it is herbaceous, erect, and co with sticky hairs. Flowers are pink, c obovoid, size of a small pea, seeds brown, and not musky.—(Dymock, 1890, i, 224).

The root is fragrant and aromatic and poss cooling and stomachic properties; it is used fever, inflammation and hæmorrhage from int organs. (U. C. Dutt). According to Taylor root is prescribed as an astringent and ton cases of dysentery. The therapeutic propert the root are probably due to the carminative of the odorous matter it contains, together the mucilaginous character commonly met in members of N. O. Malvaceæ.

(Kirtikar and Basu, p. 179 also see Chopra, page

Ilāyachī : *Elettaria Cardamomum*, *Maton.*

Vernacular names—Chhotī-ilāyachī, or ilāyachī (Hindi), Gujrati Elaich (Beng.), Elchi (Guj.), Veldoda Ella-kai (Tam.), Yālakki (Can.), Ellatari (Mal.), Vittula (Tel.).

In Sanskrit, it is known as Elā, or Upakunc There are two varieties of cardamom, the lesse (the *Elettaria*) and the greater one (the *Am*

atum); In Nighantas, the synonyms are Truti, ota-varni "grey," Kurangi and Dravidi. The ter' or Nepal Cardamom is called Sthūlailā and scribed as separately. Both kinds are consid to be digestive, pungent, light and hot, and ecommended in phlegmatic affections, such as h, asthma, piles and diseases of the bladder kidneys, Ibna Sina describes these two kinds er the names قاقلة (Kakulah).

The seeds are of a rich brown colour, about lines long, transversely rugose, with a depressed n and deeply channel raphé. The capsule is st tasteless. The seeds have a pungent, camaceous, agreeable flavour, and leave a sensation old upon the tongue when chewed.

The several varieties of cardamom are found in market, the Mysore variety: pale creamy and st; the Malabar variety: smaller and plumper; Mangalore variety: globular, large and with h skin and the wild Ceylon variety.

ical composition:

The parenchyma of the albumen and embryo aded with fatty oil and essential oil, the former ing in the seed to the extent of about 10 per . The essential oil which amounts to an

average of 4.6 per cent has the odour and fl of the seeds. It consists chiefly of a liquid h the formula $C_{10}H_{22}O_3$. According to Flüc the raw oil is dextro-rotatory and deposits a time a camphor which he considers to be ide with common camphor as it agrees with substance in optical properties and crystalline f The water which comes over when cardamom distilled contains acetic acid. The ash of cardam which according to Warnecke, amounts to per cent in common with that of several plants of the same order, is remarkably ric manganese.—(Dymock 1893, iii, 428-437).

The seeds yield 2.14 per cent of oil solu 70 per cent alcohol, has a specific gravity of at 15°, a rotatory power at 19° of +34°52′ saponification number 132. The oil co cineol, a solid terpineol of rotatory pow +83°31′ at 21° and considerable quantiti alkylic acetates (*J. Chem. Soc.* 1899, A, i —Kirtikar and Basu, page 1261.

The greater cardamom which is found in the hilly portions and Himalayas also cineole from the oil. It is used along with stimulants sometimes as a tincture and some as powder. It possesses a dark brown co

seeds which are arranged as in the true carda-, are held together in each cell by a dark viscid arine pulp. Their taste is aromatic and phoraceous.* (Finnemore, *The Essential Oils*,).

Laung : *Caryophyllus Aromaticus*, *Linn.*

cular names—Laung (Hindi), Lavanga (Sans., Mar., Can. & Guj.), Long (Beng.), Lavangalu, Lavanga-pu (Tel.), Kirambu, Kavangap-pu (Tam.).

Cloves or Lavanga appear to have been known hina as early as B. C. 266. It is regarded by krit writers as light cooling, stomachic, diges- and useful in thirst, vomiting, flatulence, colic A paste of cloves applied to forehead and is a remedy for colds. A clove roasted in the e of a lamp and held in the mouth is a ular remedy for sorethroat. Arabian name is anfal and Greek καρυοφυλλον (Caryophyllon). ammadan writers describe cloves as hot and and consider them to be alexipharmic and alic, whether taken internally or applied ex- ally; they also recommend them for streng- ing gums and perfuming the breath and on

*Also see Chopra, pp. 136, 137.

account of their pectoral, cardiacal, tonic digestive qualities. In modern medicine, clov used as carminative and stimulant, to reliev tation of throat accompanied by racking coug to deaden the pain of toothache. The oil dis from flower buds is used in perfumery and i manufacture of 'vanillin.'

The dried clove is about two-thirds of an long and consists of the calyx tube which di above into four pointed spreading sepals, mounted by a globular bud, consisting of petals and enclosing a number of stamens.

Chemical composition: Oleum Caryophyll oil of cloves which is the most important c tuent of cloves is obtainable to the extent of 20 per cent. But a greater quantity of it ma be extracted. The oil is a colourless or yell liquid with a powerful odour and taste of c specific gravity 1.046 to 1.058. It is a mixtu terpene and an oxygenated oil called eu $C_{10}H_{12}O_2$, obtainable in variable propor Eugenol has a specific gravity of about 1.0 0°C. and possesses the taste and odour of clov boiling point is 252°C. and it is optically ina The oil from clove stalks is slightly different that of the genuine clove oil, according to Schi

Co. The former has a sp. gravity 1.060 to 63, while the genuine oil has 1.067. A light from the cloves which comes over in the first od of distillation has the composition $C_{15}H_{24}$, a specific gravity 0.918 and boils at 254°. It ates the plane of polarisation slightly to the

Whilst eugenol dissolved in alcohol gives blue ur with ferric chloride, this oil gives no colour it. It is oxidised by bromine to $C_{15}H_{22}$. kett and Wright, *Journ. Chem. Soc.* 29, 1).

According to G. Laube and H. Aldendorff, percentage composition of cloves is as follows:

Water	16.39
Nitrogenous matter ...	5.99
Volatile oil	16.98
Fat	6.20
Sugar	1.32
Nitrogen free extractive ...	37.72
Cellulose	10.56
Ash	4.84

(Dymock, 1891, ii, 20-23).

According to Erdamann (*Journ. f. prakt. Chem.* 6 (1897) 146) in addition to eugenol, oil of s, but not oil of clove stems, contains some ugenol, $CH_3CO.O.C_6H_3.C_3H_5.OCH_3$. This ound can be freed from eugenol by treating it

with dilute alkali in the cold and can be pre readily by boiling eugenol with acetic anhy Its melting point is 29°, boiling point 281 density of the supercooled at 15° is 1.0842.

Eugenol also occurs in the oils of cal galangal, Japanese staranise, kobuschi, ylang- and in various other oils. (Gildemeister) *Volatile Oils*, 1913, 481).

Taj and Tamālpatra

1. *Dālchīnī or Taj*—Cinnamomum zeylar

Vernacular names—Gudatvak (Sans.), Dalchīnī, Da (Hindi, Beng.), Taj (Bom.), Lavangap-pattai (Ta

The chief constituent of the oil is ci aldehyde, though phellandrene, pinene, caryophyllene and eugenol also exist in quantities. A genuine oil from Taj conta per cent of the aldehydes. The leaves also on distillation a dark coloured oil which markedly from cinnamon bark oil. This odour resembling that of cloves and contains 70 to 80 per cent of eugenol with traces of mic aldehyde, pinene, linalol etc.

2. *Tejpatra or Tamālpatra*—Cinnam tamala or Cassia Cinnamon.

The outer bark of the plant yields on distilla- an essential oil of pale yellow colour. Cinna- aldehyde is present in the oil to about 80 per . Although this aldehyde is also the chief tituent of the bark of Taj, there is an enormous rence in the odour and flavour of the two. e tamālpatra or cassia oil, the cinnamic aldehyde l is overpowered by the terpenes etc., which rt a characteristic unpleasant odour. Accord- to Schmidt (*Chem. Zeits.*, 1891, 1376), the tial oil of the leaves is almost pure eugenol, traces of terpenes. The oil from the roots ins besides them much safrol and benzalde-

Jāyaphal: Myristica Fragrans

The Nutmeg or Mace

ular names—Jatiphalam (Sans.), Jāyaphal (Hindi and eng.), Jāiphal (Mar.), Jadikkay (Tam.), Jajikaya (Tel.).

t is difficult to trace out exactly the use of egs or mace in the days of antiquity. Besides mention in Sanskrit writings, Plautus, Pliny, Galen have also referred to this substance in works. About the year 1180, nutmegs are erated amongst the spices imported into

Accon, the port of southern Syria. At that time, they were evidently prized for fumigating purposes. From that time on, nutmegs were found in all the large markets and soon became one of the most precious spices. The distilled oils of nutmegs and mace were well known to the authors of the treatises on distillation of the sixteenth century. These oils were first examined by Caspar Neumann (1749), Conrad M. Valentine (1719), and Bonastre (1824). (Gildemeister, *The Volatile Oils*, 123).

Myristica malabarica or Bombay mace is not very much used in medicine but the volatile oil derived from it has the application in various pharmacopœial preparations like spiritus ammoniæ etc. The oil is also used in aperient pills and other preparations to prevent gripping and is given on sugar as a stimulant and carminative. The essential oil is also prized in soap and perfumery industry. The Bombay mace is deficient in the delicate aroma which is the characteristic of Myristica fragrans, and therefore, the former is used often as an adulterant to the latter.* (Chopra, 195 or Finnemore, *The Essential Oils*, 1926).

*See also *Proc. Chem. Soc.*, 1907, 285 ; 1908, 197 ; *J. Chem. Soc.*, 1908, 1653.

F—Other Substances

Kesar: Crocus Sativus or Saffron

Vernacular names—Kumkuma or Kashmirajanmā (Sans.), Kesar, Jafran (Hindi), Jafran (Beng.), Safran, Kesar (Bom.), Keshar (Mar., Guj.), Kungumapu (Tam.).

The saffron as obtained in the market consists of dried stigma and tops of styles of the flowers of Crocus sativus. The flowers are picked very early in the morning when half open. The stigmata are then separated and at once transferred to sieves, placed on earthen kilns or pots containing a slow fire. Gentle heat has to be applied otherwise the material gets soft and deteriorated.

Saffron is generally prized for its colour. Three crystalline colouring matters have been isolated out of it.

α—Crocetin $C_{24}H_{28}O_5$	M.P.	272°	0.7 per cent.
β—Crocetin $C_{25}H_{30}O_5$	M.P.	205°	0.7 per cent.
γ—Crocetin $C_{26}H_{32}O_5$	M.P.	202°	0.3 per cent.

Besides these colouring matters, there is a fatty oil to the extent of 13.4 per cent, an essential oil 1.37 per cent and a bitter substance present in traces.

Madhu: Honey

The essential constituent of honey is a mixture

of dextrose and levulose; it also contains mannite, wax, formic and other organic acids, pollen, not unfrequently alkaloidal and bitter principles from the plants, possibly derived from the pollen, small quantities of canesugar, of mineral matter, and invariably minute quantities of alcohol.

Dr. E. Sieben (Z. *der Rubenzücker Ind.*, 1884, 837) has given the following figures as a result of the analyses of some sixty samples of genuine honey:

Moisture	19.98
Grape sugar	34.71
Levulose	39.24
Invert sugar	70.30
Cane sugar by boiling with acid	1.08
Total sugar	75.03
Dry substance	80.03
Substances other than sugar ..	5.02

In some samples mannite is present to an extent of 3 per cent. It is a hexatomic alcohol, $C_6H_{14}O_6$. Dextrin is present to an extent of 28 per cent.

Drāksha: Vitis vinifera

Vernacular names—Angūr, Dākh (Hindi), Drākh (Guj.), Drāksha (Mar.), Diraksha-pazham (Tam.), Draksha-pandu (Tel.), Drakshi-hannu (Can.), Drākhya (Beng.), Raisins, Kishmish, Munakkha (Pers., Ind.).

According to *Pharmacographia*, we find that the pulp is rich in grape sugar and cream of tartar, each of which in old raisins may be found crystallised in nodular masses; also contains gum and malic acid. The seeds afford 15 to 18 per cent of a bland fixed oil, which is occasionally extracted, and which becomes thick at −15°C, and congeals to a brownish mass of the consistence of butter at about −16° to −18°C. On exposure to the air, the oil remains smeary for some time but finally dries. (Brannt). Fitz has shown that it consists of the glycerides of erucic acid, $C_{22}H_{42}O_2$, stearic acid and palmitic acid, the first acid largely predominating. The crystals of erucic acid melt at 34° C; by means of fused potash, they may be resolved into arachic acid, $C_{20}H_{40}O_2$; and acetic acid. The seeds further contain 5 to 6 per cent of tannic acid, which also exists in the skin of the fruit.

According to J. König and C. Kranch, black raisins contain: water 23.18; albuminous matter 2.72, fat 0.66, grape sugar 55.62, other non-nitrogenous matter 14.12, cellulose 1.94, ash 1.36. In the dry substance, they found nitrogen 0.56 and sugar 72.43 per cent. Sultana raisins examined by E. Mach and K. Portela yielded water 20.4,

dextrose 30.2, laevulose 36.4, pectin 1.86, free acids 1.76, malic acid 0.38, argol 3.28, insoluble matter 5.0 and ash 2.03 per cent. In the dry substance, the total sugar amounted to 83.66 per cent. (König, *Nahrungsmittel*).

The dried fruits, called raisins are used in medicine. They are described as demulcent, laxative, sweet, cooling, agreeable, and useful in thirst, heat of body, cough, hoarseness and consumption (Dutt). Mohammadan writers consider grapes and raisins to be attenuant, suppurative, pectoral, and the most digestive of fruits, purifying the blood and increasing its quantity and quality. The ashes of the wood are recommended as a preventive of stone in the bladder, cold swellings of the testes and piles.

About 0.05 mg. of arsenic is present per 100 c.cs. of fresh fruit juice (*Arbeit Kaiserl. Gesundheitsant*, 1909, 304). The unripe fruits contain a little oxalic acid also (*Ber.* 1876, 982).

Chironji: Buchanania Latifolia, Roxb.

Vernacular names—Chironji, Pyār, Piyāl (Hindi), Chironji, Piyal (Beng.), Chāroli, (Guj.), Chara, Charoli (Mar.), Moreda, Mouda (Tam.), Chara-pappo, Morala (Tel.), Nuskul, Murkalu (Can.), Chirauli (Punj.), Mura, Munga, Peru (Mal.).

Sanskrit name is Piyāla, Chāra and Tāpasa-priyā. The seeds appear to have been in use from a remote period in the preparation of sweet-meats, and as an ingredient in demulcent cough mixtures, generally in combination with dates, almonds, sesamum and cucumber seeds. Similar mixtures are also prescribed in debility. Charred slightly over the fire, they form an excellent after-dinner dish. The oil has been recommended for baldness (Dymock). It is believed to cure pimples, prickly heat and itch (Kirtikar and Basu).

The seeds have been examined by Church who found in 100 parts: water 5.7, albuminoids 27.9, mucilage etc. 2.7, oil 58.6, fibre 1.8, ash 3.3. The expressed oil of the seeds commences to congeal into a white semisolid mass at 18.5°C., at which temperature, it has a specific gravity 0.9134. It affords 95.7 per cent of insoluble fatty acids melting at 36°C. The lead soap of the fatty acids was soluble to the extent of 38 per cent in ether as lead oleate, the fatty acid from the insoluble portion melted at 57°, and possessed the characters of a mixture of palmitic and stearic acids (Dymock, 1890, i, 394).

Crossley and le Sueur obtained the following constants for the oil:

Specific gravity at 100°—0.8942.

Melting point 320°, acid value 15.4; saponification value 193.6, iodine value 57.3, Reichert-Meissel value 0.33, refractive index 1.4584; insoluble acids and unsaponifiable 95.8 per cent (Kirtikar and Basu, p. 379).

Nariyal: Cocos Nucifera Linn

Vernacular names—Nārikela (Sans.), Narryal (Hindi and Beng.), Nariyal (Guj.), Naral, Narali-mad (Mar.), Tenha, Tennamaram (Tam.), Nari-kadam, Tenkaya-chettu (Tel.), Tengina-gida, Tenginokayi (Can.), Tenga, Ten-maram (Mal.).

The Sanskrit name of the cocoanut tree is Nārikela. It is widely obtained in the East and South India, and not only the kernel of the fruit or the pulp, its various preparations also have been prescribed in Indian medicine. Dutt writes in *Materia Medica of the Hindus* (p. 247): "The water of the unripe fruit is described as a fine flavoured, cooling, refrigerant drink, useful in thirst, fever and urinary disorders. The tender pulp of the fruit is said to be nourishing, cooling and diuretic. The pulp of the ripe fruit is hard and is undigestible, but is used medicinally in the preparation called *Nārikela-Khāṇḍ*. The terminal bud of the tree is esteemed as a nourishing, strengthening and

agreeable vegetable. The root of the tree is used as a diuretic and also in uterine diseases. The oil is said to promote growth of the hair and to prevent it from turning grey...... The ashes of the leaves are used in medicine and contain much potash. The cleared shell of the nut is burnt in the fire and when thoroughly ignited covered up in a stone cup, the fluid thus obtained is rubefacient and is an effectual domestic remedy for ring-worm."

The following is the chemical composition of the fresh cocoanut kernel:

Water	46.64 per cent.
Nitrogenous substances ...	5.49
Fat	35.93
Non-nitrogenous extract ...	8.06
Lignin	2.9
Ash	0.97

The kernel when dried yields nitrogen 1.65 and nitrogen free extract 67.33 per cent. (König in *Hamerbacher Landw. Versuchssk*, Bd. 13, S. 243).

Palm sugar examined by P. Horsin Deon (1879) yielded water 1.86, canesugar 87.97, invert sugar 9.65, other substances 0.50 per cent, and when dried 89.64 per cent of canesugar. The other organic substances consisted of 1.71 per cent

reducible sugar, 4.88 gum, and 3.06 mannite and fat.

(König, *Nahrungs-mittel*).

The milk of ripe and unripe cocoanuts has been analysed by L. L. van Slyke, the composition being as follows :

	Unripe	Ripe
Water at 60° ...	95.00%	91.23%
Ash	0.617	1.06
Glucose	3.973	traces
Cane sugar ...	traces	4.42
Proteids	0.133	0.291
Fat	0.119	0.145

Cocoanut oil has a peculiar complex composition. It is chiefly composed of laurin and myristin, but contains also six other glycerides including caproin, caprylin, caprin, palmitin, stearin, and olein. The amount of stearin present is very small. Lewkowitsch found only 0.99 per cent of stearic acid, while Hehner and Mitchell none. The volatile acids are chiefly capric and caprylic.

Elsdon (*Analyst*, 1912, 38, 8) has given the following figures for the analysis of the cocoanut oil :

Acids	per cent	Acids	per cent
Caproic	2	Myristic	20
Caprylic	9	Palmitic	7
Capric	10	Lauric	45
Stearic	5	Oleic	2

Cocoanut oil has the specific gravity 0.9259 at 15°C. and the melting point between 20° and 28°, whereas the melting point of the fatty acids is 24-25°. Saponification value of the oil is 246-262 and the iodine value 8.2-9.5.

CHAPTER III

THE PRODUCTS OF COMBUSTION

The analyses of various substances which are used as fire oblations have been given in the previous chapter. It will be seen from there that the substances partaking in the process are so varying, their chemical nature so different and the conditions under which their combustion takes place so unspecified, that it is difficult to interpret the process on an exactly scientific basis. An attempt will be made here in the least tentative way to see whether it is possible to have an idea of the nature of products which are given out as a result of their combustion.

The combustion products appear to depend upon the following conditions :

(*a*) The nature of substances used and also to some extent their proportions.

(*b*) The temperature attained during the various stages of combustion at the various places in the fire pot.

(*c*) The limitations of the supply of air.

(*d*) Interactions amongst the products formed.

(*e*) The changes on account of the environments as the products diffuse in the surroundings, under the influence of various agencies, especially light.

Substances undergoing Combustion

As has been stated in the first chapter, the classical method of division included four groups of substances used as fire oblations : (i) substances with fine odour, (ii) substances with healthy constituents, (iii) sweet substances and lastly, (iv) the medicinal herbs. The idea underlying this classification will perhaps not give much satisfaction to a modern chemist. According to the old view, the substances are reduced to a finer state under the action of fire, and thereby, if inhaled along with air, they would be more efficacious than what they would have been, if consumed in their gross form. It was further reasoned that for ordinary health and pleasure, one requires (i) sweet smelling, (ii) sweet tasting, (iii) substantial and (iv) disease curing medicinal substances. And therefore, in their choice for selection of oblations, the ancients sorted out things of the four classes mentioned above. To them, the action of fire meant only the reduction of the gross substances to the finer state and no more. We know that the

true nature of combustion was unknown to the chemists also upto the days of Lavoisier in the eighteenth century, and so by the mere fact that the ancients did not know the mechanism of combustion, the significance of the whole process of Agnihotra is not to be ignored. On the analogy, that water becomes more energetic steam, whilst the essential nature of it remains unchanged, they were led to think that during combustion or the application of heat, the essential nature of the substances put into the fire remains the same, while the change occurs in the form. But any way, by experience, they selected out substances to be offered to fire such which proved to be beneficial to them. It was a matter of their experience and they were confident of it that the oblations offered to fire, purified air and the environments became more cheering and healthy. They were also aware of the fact, only as a result of their experience here too, that this process saved them from the attack of various infectious diseases. So in spite of it, that the old people did not follow the mechanism of combustion to a correct extent, they happily in their own arbitrary and experienced way, drew out a list of the substances, which even today would appear commendable.

Now, we shall give here a summary of the products which are used as offerings to the fire from a chemist's point of view:

1. *Wood*—Wood is composed principally of cellulose and ligno-cellulose in about equal quantities, together with gums, resins, a variable amount of water and the inorganic matter left as ash. Cellulose has the composition $(C_6H_{10}O_5)_x$ and is the principal constituent of the cell membranes of the young plants. Ligno-cellulose is the substance with which the cellulose of young plants becomes incrustrated as it grows old and becomes woody fibre. Wood contains a pretty high percentage of water even when it has been well dried and seasoned; in fact, the minimum is near about 15 per cent. Wood has only a low calorific value; in spite of it, it is largely used as a household fuel in India as it is easily procured. The following figures give an idea of the wood composition:

Wood	Carbon	Hydrogen	Nitrogen	Oxygen	Ash	Calories
Oak	50.16	6.02	0.09	43.36	0.37	4620
Beech	49.06	6.11	0.09	44.17	0.57	4774
Birch	48.88	6.06	0.10	44.67	0.29	4771
Fir	50.36	5.92	0.05	43.39	0.28	5035
Pine	50.31	6.20	0.04	43.08	0.37	5085

(*J. Chem. Soc.*, Vol. XLVI, 477 (1884))

It will be seen from this table that wood ordinarily contains 50 per cent of carbon, 43 per cent oxygen and 6 per cent hydrogen and 0.5 per cent of inorganic ash and nitrogen only in traces. In Agnihotra, wood forms the base in combustion and is used only to an extent of minimum to keep the fire burning. In spite of it, this minimum amounts to about 70 per cent or more of the total weight. Most of the woods used for the purpose do not contain a high percentage of resins, oleo-resins, gum resins or gums, which are the products derived from exudations of plants. Aromatic woods, as Chandan, Agar, Tagar and pine wood contain essential oils also. Palāsh wood to some extent contains an oily ingredient, which is abundant in seeds.

Not only wood, but a greater portion of the fumigating mixture also contains similar substances which form the base for combustion. Cellulose and ligno-cellulose in the powder of sandal wood, Nāgarmothā, Bālchhar, Kapūr-kī-Kachrī and other substances do not form an insignificant portion.

2. *Carbohydrates*—Undoubtedly, cellulose and other allied bodies belong to the group of complex carbohydrates. Simpler bodies of carbohydrates are also present in the fire-oblations. They may be

classified as follows :

Starch—It forms a large bulk of rice and preparations from it. The figures for starch content are as follows :

Rice	78 per cent	Kapūr Kachrī	52.3
Barley	71	Nar-kachura	17-19
Malt	67		
Tagar	14		

Sugars—Canesugar, $C_{12}H_{22}O_{11}$, forms about 10 per cent of the bulk of the oblations. It might be added more also and sometimes, in absence of other substances it might be used singly. It may be added in the crystalline form or even as *gurh* in the unclarified form. Other substances containing sugar are :

Milk	5 per cent lactose (galactose, glucose)
Wheat	1.44
Nar-Kachura	1.00
Cloves	1.32
Tagar	5-6
Honey	75.0 (laevulose, grape sugar etc.)
Raisins	55.6

3. *Fatty substances*—Clarified butter or ghee undoubtedly forms a very important bulk in the whole process. Other vegetable oils are rejected for the purpose, though the market variety of ghee is very often adulterated with such substances. Other subs-

tances which contain fatty acids are the following:

Rice	..	..	0.5 per cent
Barley	..	..	1.7
Malt	..	..	2.6
Wheat	..	..	1.7
Til	..	..	50-55
Sandal wood	..	..	3–6
Agar	..	..	1.0
Tagar	..	..	0.56
Nar-kachura	..	..	4.0
Cloves	..	..	6.2
Chironjī	..	..	58
Cocoanut	..	..	36

Fatty acids of ghee are oleic, palmitic, stearic, myristic and other acids. Cocoanut fats are myristic, lauric, caprylic, palmitic and stearic acids and traces of other acids also. The acids from chironjī are also of palmitic-stearic type. Other fats may also be similar glycerides of saturated and unsaturated fatty acids.

4. *Aromatic substances*—These substances are mostly responsible for the readily volatile aroma which appears to be so characteristic of the fumigating substances. When butter is crackled, the pleasant odour given out is due to the more volatile fatty acids, and is distinctly different from the aromatic odour given out by phenolic substances. Only

a few of the aromatic substances have been identified fully in the fumigating mixture constituents.

Substances giving aroma may be divided into two groups : (i) those belonging to the phenolic series. They may be either simple polyhydric phenols, or phenolic ethers or in some cases, esters also ; (ii) those belonging to terpene and camphor series, especially, of olefinic groups. The following substances generally exist :

Thymol (or isopropyl-m-cresol) $CH_3.\ C_6H_3.\ (OH).\ C_3H_7$.

Carvacrol (or isopropyl-o-cresol), the ortho-isomer of thymol.

Anethol (or p-propenyl anisol), $C_6H_4\ (OCH_3)\ (CH : CH.\ CH_3)$ and other anisol derivatives.

Eugenol, $C_6H_3\ (OH).\ (OCH_3)\ (CH_2.\ CH : CH_2)$ and aceteugenol, and also isoeugenol.

Coumarin derivatives, $C_6H_4 < (O)\ CH : CH.\ CO >$, and coumaric acid esters.

Safrol, $C_6H_3.\ (< O.\ CH_2.\ O >).\ (CH_2.\ CH: CH_2)$ and isosafrol.

Myristicin (4-allyl-6-methoxy-1, 2-methylene-dihydroxybenzene) $C_{11}H_{12}O_3$.

Esters of cinnamic acid, $C_6H_5CH: CH.\ COOH$; salicylic acid, $C_6H_4\ (OH)\ COOH$; anisic acid (p-methoxybenzoic acid), $C_6H_4\ (OCH_3)\ COOH$;

and veratric acid (dimethoxybenzoic acid) C_6H_3 $(OCH_3)_2$ COOH.

Camphor used nowadays is either the natural or the synthetic one. Camphor and camphor oil yield substances like pinene, phellandrene, cineol, dipentene, terpineol and sesquiterpenes. Deodār wood or pine wood contains pinene and allied compounds mostly in the oil. Pinene also occurs in the oils from galangal, star anise, nutmeg and in camphor also. The following products appear to be directly occurring or indirectly associated with substances like sandal wood, Agar, Tagar, Deodār, Gūgal, Bālchhar (Jatāmānsī), Karchura (C. zedoria), greater cardamom and other substances :

d– Terpineol, $C_{10}H_{18}O$, in cardamom and others.

l–α– Terpineol, in wood turpentine and camphor oils.

Borneol, $C_{10}H_{18}O$, from Jatāmānsī.

Fenchyl alcohol, $C_{10}H_{17}$. OH, from pine.

Santalols, $C_{15}H_{24}O$, in sandal wood.

Cedrol, $C_{15}H_{26}O$, in cedar wood.

Citral, $(CH_3)_2C : CH. CH_2. CH_2. C (CH_3). CH.$ CHO in sassafras and cinnamon oils.

Cineol, $C_{10}H_{18}O$, in Kulanjan, and certain cardamom oils.

d–pinene, $C_{10}H_{16}$, in Kulanjan and others.

In most of the cases, products similar to those described above are also found. It is difficult to say that they are present in their simple form in the volatile portion of the oils. It is very likely that the volatile oils are complicated and complex mixtures of a number of constituents, nearing one another in composition.

5. *Resinates and tannates*—Besides celluloses, ligno-celluloses, carbohydrates, fatty substances and volatile oils, most of the substances contain some percentage of resinous matter also. Gums are also associated to a small extent. From some extracts, tannates can also be precipitated.

6. *Nitrogenous matter*—This does not form an essential constituent of the fire oblations. Undoubtedly, substances, prepared from milk; grains, like wheat, malt, barley, sesame and others, and odoriferous substances like Nar-Kachura, Jatāmānsī, and others contain a high percentage of nitrogen mostly present as albuminoid material as is seen from the following figures:

	Per cent		Per cent
Milk	3–6	Sesame (oil cake)	33
Rice	7	Tagar	13
Barley	12	Kapūr Kachrī	2–4
Malt	13	Nar-Kachūra	23
Wheat	13	Karchūra	36
Raisins	0.5	Cloves	6
Cocoanut	5.5	Chironjī	28

Most of the protein is of the vegetable origin, while animal products, besides those from milk, are very particularly excluded. Milk contains lact-albumins and lact-globulins. Most of the vegetable proteins are of globulin class, whilst seeds contain leucosins and legumelins, or *edestins*, and nuts contain *excelsin* type of globulins. Seeds specially cereals, contain glutelins and gliadins also; e.g., *gliadin* of wheat, *hordein* of barley. On hydrolysis, they yield glutamic acid and argenine. Casein from milk is a phosphoprotein.

7. *Inorganic constituents*—These are the constituents which perhaps play the least rôle in the combustion during the fumigation process, and are left behind in the form of an ash which is distinctly alkaline in nature. Most of it is the potash ash, contaminated with a small percentage of soda and lime. Magnesia also forms an important part, whilst traces of iron are also found in some

cases. Acids are mostly phosphate, but also sulphate and sometimes chloride. Silica is present to a considerable extent.

Composition of Fumigants

It is difficult to specify any particular proportion in which different substances are mixed up to form an ideal for fire-oblations. A suggestive list has been kindly drawn up for me by Pandit Vidyānandji of Kāshī (Benares) which is given here to give an idea :

1 seer = 2 lbs. or 970 g. = 16 chhatank.

Wood 10 Seers—Clarified butter (Melted) 2 Seers

	Chhatānk		Chhatānk
Jau (Yava, Barley)	4	Guggul	1
Til (Sesame)	4	Nāgarmothā	1
Rice	4	Bālchhar	1
Makhānā	4	Narkachūra	1
Kishmish	2	Sugandhabālā	1
Cocoanut	2	Ilāyachī	½
Chhuhārā	2	Jāyaphal	½
Chironjī	2	Lavanga	½
Almonds	2	Tumul	1
Pistā	1	Taj	1
Sandal powder	2	Tejpāt	1
Deodār	2	Tālis patra	1
Agar	1	Kulanjan	1
Tagar	1	Sugar	4
Kapūrkachrī	1		

Volatility of Substances

As the fumigation process depends highly on the boiling point of the volatile oils and the vapour tension, the boiling points of some of the substances are given below:

Sandal wood oil	300° and 310°		
Camphor oil	160°–210° (sublimation)		
Cloves oil	252°		
Thymol	232°		
Carvacrol	236°		
Anethol	233–234°		
Eugenol	252°		
Aceteugenol	281°		
Coumarin	291°		
Safrol	485°	Isosafrol	253°
Myristicin (40 mm.)	172°	Santene	140°
Pinene	155°	Terpineol	217°
Borneol	212°	Fenchyl alcohol	201°
Santalol	301°	Cedrol	293°
Citral (23 mm.)	122°	Cineol	176°

On account of the low vapour tensions, most of the oils get volatilised at even ordinary temperatures and therefore, they diffuse their aroma in the surrounding atmosphere very easily.

Many of the oils owe their characteristic odour on account of the presence of certain fatty aldehydes in minute traces; for example, capronic aldehyde in oil of Eucalyptus Globulus, n-octylic aldehyde, in lemon oil and n-nonylic aldehyde in orris root and cinnamon oils. It is very likely

that many of the fatty oils also owe their characteristic odour on account of higher fatty aldehydes.

Sometimes where the aromatic alcohols are present in the substances used for fumigation, they are also oxidised to aldehydes and give rise to smelling substances like cuminic aldehyde, C_3H_7. C_6H_4. CHO (p-isopropyl benzaldehyde) b.p. 232°, anisic aldehyde, CHO, $C_6H_4.OCH_3$ (p-methoxybenzaldehyde) b.p. 248°, etc. Furfurol, C_4H_3. O. CHO, b.p. 161°, is present as such in pine tar oil, clove oil, the oil of cinnamon, and sandal wood oil. The oil of cloves contains a small amount of vanillin, CHO. C_6H_3. $(OCH_3)(OH)$, b.p. 285° (in a current of CO_2). Cinnamic aldehyde C_6H_5. CH : CH. CHO, b.p. 252°, occurs in cinnamon root oil (from Taj and Tamālpatra).

Temperature Variation

The fumigation process, with which we are concerned here, is subjected to wide variations of temperature. In the first chapter, an account has been given of the nature of fire-pot and the arrangement of wood sticks in the pot. It may be again mentioned here, that the pot is a hollow pyramid, with a closed narrow base and a wide open square at the top. It is only the top which

is exposed, whilst the rest of it is either metal covered or is placed under ground. Nearly two-thirds of the pot is loosely packed up inside with sticks, arranged side-wise, and cross-wise one above the other. A small passage is allowed in the centre to introduce the initial fire, which is usually the inflamed camphor. From camphor, the small chips of wood dipped into butter catch fire, and by and by, all the sticks get inflamed. At intervals, regulated by the pitch of hymns and aphorisms, melted butter is poured into the fire in small amounts. At a later stage, when the fire has been awakened to a considerable extent, solid oblations are added at the well defined intervals, and side by side, butter is also poured over it. Offerings are given in the centre of the fire where all the oblations gradually get packed. At this stage, vigour of the fire is markedly subsided, and the combustion takes place slowly under a *limited supply* of air. In ceremonies performed on a large scale, it takes about 24 hours or more for the fire to extinguish completely. The daily fire gets subsided within a couple of hours or so.

The combustion of the wood starts with the ignition of cellulose and ligno-cellulose material, and by and by, other hydrocarbons are also pro-

duced, which get ignited at different flash-points or ignition temperatures. The temperature of ignition is the temperature at which the heat evolved by the oxidation reaction just counterbalances the loss of heat by radiation etc., that is, it is the temperature at which rapid combustion becomes independent of external supply of heat.

A greater portion of fire pot underneath is subjected to a temperature of about 300°C., whilst at a point just above the flames, the temperature might reach upto about 1200° to 1300°. Then, of course, there are the regions where the temperature varies between these two extreme limits. When flames have subsided, the temperatures are mostly within the range of 250° to 600°, and in fact this is the region where the most effective fumigation takes place under a limited supply of air.

Ignition temperatures of a few hydrocarbons in air or oxygen are given below from the investigations of Dixon and Coward (*Trans. Chem. Soc.*, 1909, 95, 514).

Gases	*Ignition Temperature °C.*
Methane -Oxygen	556-700
Methane -Air	650-750
Ethane-Oxygen	520-630
Ethane-Air	520-630

Gases	*Ignition Temperature °C.*
Propane-oxygen	490-570
Ethylene-oxygen	500-519
Ethylene-air	542-547
Acetylene-air	416-440
Propylene-oxygen	497-511 (Meyer and Munich, *Ber.*, 1893, 26, 2421)
Isobutane-oxygen	545-550
Isobutylene-oxygen	537-548 (Meyer and Munich, *Ber.*, 1893, 26, 2421)
Coal gas-air	878

Thus most of the hydrocarbons require a temperature of 500° to 600°, and as such, in the colder regions of the fire-pot, specially when the flame has subsided, it is very likely, that the hydrocarbons diffuse out as such into the surrounding atmosphere, undergoing frequently, partial oxidations and various products are formed.

Generation of Hydrocarbons

The combustion of fuel is essentially the oxidation of carbon and hydrogen constituents to carbon dioxide and water. Cellulose and ligno-cellulose of wood have the general composition of $n(C_6H_{10}O_5)$ and the dried sample contains at least 20 per cent of moisture. As the molecule of cellulose contains in itself the amount of oxygen sufficient to oxidise whole of the hydrogen to water, it is mainly the oxidation of carbon which is responsible for the

heat production. Carbon is either liberated free in form of soot when the supply of air is deficient and the combustion improper, or it forms carbon monoxide and dioxide according to the following equations :

$$\text{(i)} \quad n(C_6H_{10}O_5) = 6nC + 5nH_2O$$
$$\text{(ii)} \quad n(C_6H_{10}O_5) + 3nO_2 = 6nCO + 5nH_2O$$
$$\text{(iii)} \quad n(C_6H_{10}O_5) + 6nO_2 = 6nCO_2 + 5nH_2O$$

The average calorific value of cellulose amounting to 4150 calories is utilised by other reactions occurring simultaneously or is dissipated as heat. It is also utilised as the latent heat for the volatilisation of volatile constituents of many substances. Where the temperature is not high, and the decomposition least probable, this energy might also be used up for the combination of carbon monoxide with water to form formaldehyde according to the following equation :

$$2CO + 2H_2O = 2HCHO + O_2$$

Formaldehyde is, however, mainly synthesised from other sources which will be discussed hereafter.

Besides the complete combustion of cellulose material of the wood, it is subjected to a very important process from our point of view known

as the distillation of wood, which we are going to describe in the subsequent article. This is really the process which gives rise to the production of many important hydrocarbons and their derivatives.

Distillation of Wood

The way in which the sticks are arranged and the conditions of temperature and air supply, all favour the specifications necessary for wood distillation. Cellulose being a complex organic substance, the chief influence of heat is naturally to decompose it into simpler compounds. From its composition, it would be expected, that by driving off the water, 44.45 parts by weight of charcoal would be obtained. It breaks down, however, into more complex substances than water and carbon.

Cellulose may be considered a hexahydric alcohol, $C_{12}H_{14}O_4(OH)_6$. From the yield of charcoal, the following products of distillation might be written :

$$C_{12}H_{20}O_{10} = 8C + C_4H_{20}O_{10}$$
$$100 = 29.6 + 70.4$$

In order to follow up the subsequent changes, the view advanced by Brannt may be considered. He propounded his views mainly from the vinegar manufacture considerations, but the steps pointed

out by him may be representative here at least qualitatively, if not to the exact precision. The products obtained in the course of fumigation process might be easily explained on their basis :

The $C_4H_{20}O_{10}$ may be considered to have arranged itself in various ways in order to form the tar products, acetic acid, methyl alcohol and other gases. Of the possible changes, the following may be taken to be typical :

1. $C_4H_{20}O_{10} = 2\ \underset{\text{acetic acid}}{CH_3COOH} + \underset{\text{water}}{6H_2O}$

2. $CH_3COOH = \underset{\text{methyl alcohol}}{CH_3OH} + CO$

3. $\underset{\text{acetic acid}}{CH_3COOH} = \underset{\text{marsh gas or methane}}{CH_4} + CO_2$

4. $\underset{\text{acetic acid}}{2CH_3COOH} = \underset{\text{acetone}}{CH_3COCH_3} + CO_2 + H_2O$

5. $CH_3COOH + CO = \underset{\text{acetaldehyde}}{CH_3CHO} + CO_2$

6. $\underset{\text{methane}}{2CH_4} = \underset{\text{acetylene}}{C_2H_2} + 3H_2$

7. $10CH_4 = C_{10}H_8 + 16H_2$.

The products of distillation seem to be water, fatty acids, hydrocarbons, phenols, guaiacol, alcohols, aldehydes and ketones. The methyl group seems to be predominant. The mode of

decomposition is difficult to determine, and the process can only be speculated from the products formed. The usual products detected in the course of fumigation are acetic acid, formaldehyde and acetaldehyde, phenols and some of the hydrocarbons, which in most of the cases are destroyed in subsequent reactions in the vicinity of inflammation. The methyl products detected may be also formed from the decomposition of ligno-cellulose. Some of the products are, undoubtedly, the result of the distillation of resinous bodies also, which are either present in wood or in the fumigation mixture.

Distillation of Resinous Wood

From the distillation of hard woods and resinous woods too, the products obtained are furfural and various products of pyroligneous acid. The acid in the fumigation process never comes out as such. It mostly undergoes subsequent oxidation, while a few of the constituents diffuse over in the surrounding atmosphere.

The chief products obtained from the distillation of the resinous wood are turpentine and tar products. Terpineol appears to be chief product of turpentine while other substances like terpin, cineol and other volatile constituents which have

been described in previous sections also come out. Formaldehyde forms a very important constituent in the combustion and distillation of resinous wood, and phenolic substances also accompany it.

Steam Volatilisation of Odorous Substances

It has already been remarked that the temperature attained at various places varies between 250° and 600°, while in the actual flames it can go as high as 1300°. The boiling points of volatile constituents of the fumigation mixture have already been considered, which lie within 300° in most of the cases. By mere virtue of their boiling points, the substances can diffuse over in the surroundings, and the vaporisation gets more facilitated in some cases on account of the reduction of pressure inside the system for various reasons.

But the more important rôle is played by steam in carrying over the vapours of volatile aromatic oils and some of the fatty constituents, and the process becomes analogous to that of steam distillation. When celluloses and other carbohydrates and complexes undergo combustion, steam is undoubtedly formed in copious quantities by the combination of hydrogen of organic bodies with the internal oxygen or the oxygen of the

atmosphere. This is how, it is possible for substances like thymol, eugenol, aceteugenol, carvacrol, coumarins, pinene, borneol, terpineol, cineol, and various esters of coumaric, cinnamic and other acids to be carried over to distances in the atmospheric surroundings. The aroma can be smelt and sometimes distinguished even at a distance, and persists for hours after the inflammation of the fire has ceased.

Mechanical Volatilisation of Perfumes through Smoke and Further Diffusion through Air

Another important source which helps in the diffusion of the volatile aromatic, and even aldehydic and acidic substances of aliphatic series, is through the agency of smoke. The process is merely a mechanical one and resembles the process of absorption at the solid-gas or even solid-liquid interface. Smoke functions in a way as a colloidal vehicle, and by the surface actions, the volatile constituents are carried over. Smoke is well known to carry over acidic constituents by a process like this and aldehydes also get diffused in a similar manner. Needless to say, that the fumigation process under consideration is the one in which smoke is also given out in copious quantities, and the solid

particles existing in a highly divided state offer sufficient surface for this mechanical diffusion. The temperature effect and the wind direction subsequently play a very important part in the wide spread of the products.

Partial Combustion of Fatty Substances

In the fumigation ceremony, offerings of butter play a very conspicuous part. There are a number of other fatty substances also of the vegetable origin, which have already been referred to before. Butter ordinarily helps in the rapid combustion of cellulose and lignocelluloses of wood and keeps the fire inflaming. The fumigating mixture also undergoes proper combustion in its presence.

Fatty substances are combinations of fatty acids and glycerol. Glycerol being a trihydric alcohol, it forms mono-glycerides, diglycerides and triglycerides. It is not necessary that the triglyceride should be derived from one and the same fatty acid. The author believes, that in butter such a case occurs and a mixed triglyceride is formed. Oleic, palmitic, stearic and myristic acids form major portion of the products of hydrolysis of butter, and therefore, a representative triglyceride may be assumed to have the following constitution :

$$\begin{array}{ll} CH_2.O.CO.C_{17}H_{33} & \text{.. (oleic)} \\ | & \\ CH.O.CO.C_{15}H_{31} & \text{.. (palmitic)} \\ | & \\ CH_2.O.CO.C_{13}H_{27} & \text{.. (myristic)} \end{array}$$

The acids derived from butter have the following constitutions :

Saturated Acids

Butyric acid, $CH_3CH_2.CH_2COOH$ (C_3H_7COOH)	4 p. c.
Caproic acid, $CH_3(CH_2)_4.COOH$ ($C_5H_{11}COOH$)	2 p. c.
Caprylic acid, $CH_3(CH_2)_6.COOH$ ($C_7H_{15}COOH$)	0.9 p. c.
Capric acid, $CH_3(CH_2)_8.COOH$ ($C_9H_{19}COOH$)	2 p. c.
Lauric acid, $CH_3(CH_2)_{10}COOH$ ($C_{11}H_{23}COOH$)	4-4.5 p. c.
Myristic acid, $CH_3(CH_2)_{12}COOH$ ($C_{13}H_{27}COOH$)	10 p. c.
Palmitic acid, $CH_3(CH_2)_{14}COOH$ ($C_{15}H_{31}COOH$)	26-31 p. c.
Stearic acid, $CH_3(CH_2)_{16}COOH$ ($C_{17}H_{35}COOH$)	10-12 p. c.

Unsaturated Acids

Oleic acid, $CH_3.\ (CH_2)_7.\ CH : CH.\ (CH_2)_7.\ COOH$ ($C_{17}H_{33}.\ COOH$) 30-40 per cent.

Linoleic acid, $CH_3.\ (CH_2)_4.\ CH : CH.\ (CH_2)_4.\ CH : CH.\ (CH_2)_4.\ COOH$ ($C_{17}H_{31}.\ COOH$) 4-5 per cent.

Til or sesame oil contains mostly the glycerides of elaidic acid (which is a geometric isomer of oleic acid) and also of stearic acid. Fatty products from other substances are also of the similar type.

The problem of the combustion of fats may be

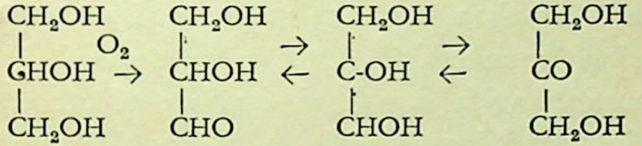
reduced to the combustion of (i) glycerol and (ii) of fatty acids.

Combustion of glycerol: The combustion is partly dehydration and partly oxidation process and gives rise to two very important products; acrolein and formaldehyde.

$$\underset{\text{Glycerol}}{C_3H_5(OH)_3} = \underset{\text{acrolein}}{CH_2{:}CH.CHO} + 2H_2O$$

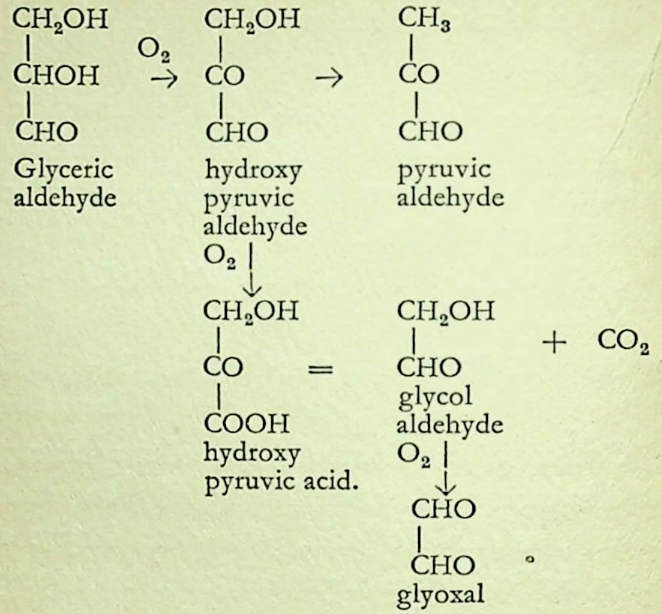
$$CH_2{:}CH.CHO + 5O = 2CO_2 + H_2O + \underset{\text{formaldehyde}}{CH_2O}$$

Oxidation reactions of glycerol may be represented in many other ways giving rise to various products, as glyceric acid, glyceric aldehyde and various bodies derived from acetone and isopropyl alcohol.



Glycerol Glyceric aldehyde Triose-enediol Dihydroxy acetone

But from our point of view, the more important is the formation of pyruvic aldehyde, $CH_3CO.CHO$ and glyoxal. These compounds are closely related to the glycerol constitution :



Such products are formed not only from glycerol but from carbohydrates also by various oxidation reactions, i.e., in the process of slow combustion with regulated amount of air and specified conditions, and in solutions by oxidations with permanganate, in acid, neutral and alkaline media as has been well discussed by de Bruyn and van Ekenstein (various papers in *Rec. trav. chim.*, 1895-1897) and W. L. Evans and collaborators (*J. Amer. Chem. Soc.*, 1919-28, see Evans': "Mechanism of Carbohydrate Oxida-

tion," *Chemical Reviews*, 1929, 6, 281-315). As in case of glycerol, so in all sugars also, the combustion process is partly dehydration and partly oxidation. A well-known product of dehydration is caramel, a brown colouring matter of very uncertain constitution. The ultimate products of oxidation in all these cases are acetaldehyde, then formaldehyde and finally carbon dioxide and water. The volatile products out of all these escape and diffuse out in air without undergoing the final fate immediately.

Combustion of fatty acids: It has already been stated that fatty acids from butter and other oily constituents are mostly of two groups, the saturated one and the unsaturated. Their combustion includes three processes, (i) the direct oxidation to carbon dioxide and water, (ii) decomposition to lower fatty acids and hydrocarbons; lower fatty acids giving out carbon dioxide and leaving simpler hydrocarbons, (iii) the unsaturated fatty acids breaking at the double bond during the course of oxidation and giving aldehydes of fatty series. Ultimately in this case also, the complete combustion leads to carbon dioxide and water.

The generation of hydrocarbons may be represented as to be taking place in two steps:

addition of a molecule of water and then its elimination :

$$\underset{\text{Caproic acid}}{\underset{H}{CH_3CH_2CH_2}\,\vdots\,\underset{OH}{CH_2CH_2COOH}} \rightarrow CH_3CH_2CH_3 \text{ (propane)} + \underset{\beta\text{—hydroxypropionic acid}}{OHCH_2CH_2COOH}$$

$$\downarrow$$

$$\underset{\text{acrylic acid}}{CH_2 : CH.COOH} + H_2O$$

$$\downarrow$$

$$\underset{\text{ethylene}}{CH_2 : CH_2} + CO_2$$

Thus from caproic acid, propane and ethylene are obtained *via* acrylic acid formation. Similarly, higher fatty acids may give rise to a number of simpler saturated and unsaturated hydrocarbons in the stage of combustion; as has been shown in the following scheme. From palmitic acid :

$$\underset{H}{CH_3CH_2}\,\vdots\,\underset{OH}{CH_2.CH_2.CH_2.CH_2}\,\vdots\,\underset{H}{CH_2.CH_2.CH_2.CH_2}\,\vdots\,\underset{OH}{CH_2.}$$

$$\downarrow \qquad \underset{OH}{CH_2.CH_2.CH_2}\,\vdots\,\underset{H}{CH_2.COOH}$$

$$\underset{\text{ethane}}{CH_3.CH_3} + OH(CH_2.CH_2.CH_2.CH_2)\,OH + \underset{\text{butane}}{CH_3(CH_2)_2CH_3} +$$

$$\downarrow$$

$$\underset{\text{butadiene}}{CH_2 : CH.CH : CH_2}$$

$$OH(CH_2)_4OH + \underset{\text{acetic acid}}{CH_3COOH}$$

$$\downarrow \qquad\qquad \downarrow$$

$$\underset{\text{butadiene}}{CH_2 : CH.CH : CH_2} \qquad \underset{\text{methane}}{CH_4} + CO_2$$

Thus during the process of combustion,

palmitic acid is reduced to a number of hydrocarbons as methane, ethane, butane and butadiene.

In the unsaturated fatty acids, combustion in the first stage is an oxidation reaction at the double bond, and aldehydes are formed : From oleic acid,

$$\begin{array}{l} CH_3\ (CH_2)_7CH : CH.\ (CH_2)_7.COOH \\ \qquad\qquad\qquad O : O \\ \qquad\qquad\qquad \downarrow \\ CH_3.(CH_2)_7CHO + CHO.(CH_2)_7.COOH \\ \qquad\qquad\qquad \rightarrow CHO.(CH_2)_6CH_3 \text{ n-octylic aldehyde} + CO_2 \\ \text{n. nonylic aldehyde} \end{array}$$

Similarly, capronic and valeric aldehydes are obtained from linoleic acid. The characteristic odour given out when butter is crackled by heating is due to the volatilisation of aldehydes of this nature. The further combustion of aldehydes oxidises them to acids and then hydrocarbons are formed by the elimination of carbon dioxide :

$$\begin{array}{l} CH_3CH_2CH_2CH_2CHO \quad \text{valeric aldehyde} \\ \qquad\qquad \downarrow O_2 \\ CH_3CH_2CH_2CH_2COOH \quad \text{valeric acid} \\ \qquad\qquad \downarrow \\ \underset{\text{butane}}{CH_3CH_2CH_2CH_3} + CO_2 \end{array}$$

Slow Combustion of Hydrocarbons

We have seen how fatty substances give rise to simpler hydrocarbons during the process of combustion. Oxygenated hydrocarbons are also

produced from carbohydrates by the way of dehydration in the initial stage and then oxidation. Thus from glucose :

$$CH_2OH.CHOH.CHOH.CHOH.CHOH.CHO$$
$$\rightarrow CH_2 : C(OH).CH : C(OH).CHOH.CHO$$
$$\rightarrow CH_2 : C(OH).CH : C(OH).CHOH.COOH$$
$$\rightarrow CH_2 : C(OH).CH : C(OH).CH_2OH + CO_2$$

The last product may then break up to give a number of simpler unsaturated hydrocarbons and alcohols. These alcohols now in their turn might be oxidised to aldehydes and ketones.

The oxidation of these hydrocarbons during the course of subsequent combustion leads to the formation of such products, which are very important from our fumigation point of view. Formaldehyde is formed during the slow oxidation of methane at 450° to 500°c, and can be detected as a transient intermediate product. Bone and Wheeler (*Trans. Chem. Soc.*, 1903, **83**, 1074) came to the conclusion, that the slow combustion of methane takes place in several stages, of which the formation of formaldehyde is the initial step. Armstrong (*Trans. Chem. Soc.*, 1903, **83**, 1088) however, thinks that it is the methyl alcohol which is the first product formed. Bone's subsequent steps, as sum-

marised by Wheeler and Blair (*J. Soc. Chem. Ind.*, 1923, **42**, 89T) are given in the following table:

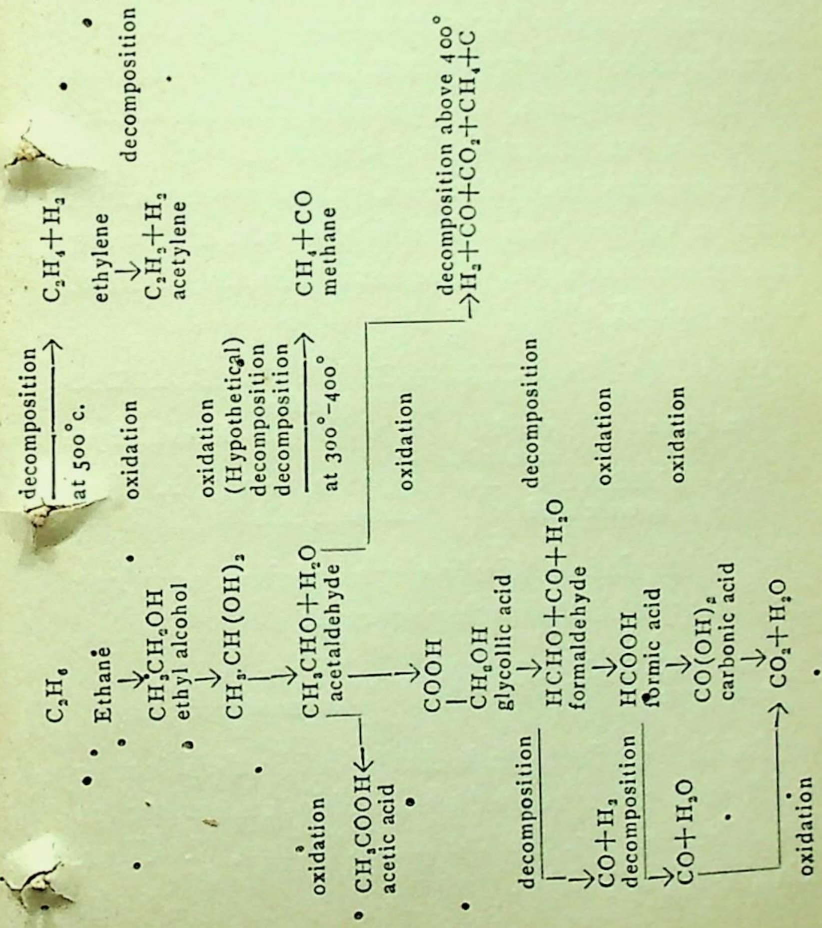
$$\underset{\text{methane}}{CH_4} \xrightarrow{O_2} \underset{\text{methyl alcohol}}{CH_3OH} \xrightarrow{O_2} \underset{\substack{\text{methylene glycol}\\\text{(hypothetical)}}}{CH_2(OH)_2} \rightarrow \underset{\text{formaldehyde}}{CH_2O} + H_2O \xrightarrow{O_2} \underset{\text{formic acid}}{HCOOH}$$

$$\rightarrow \underset{\text{carbonic acid}}{CO(OH)_2} \rightarrow CO_2 + H_2O$$

Formaldehyde so formed escapes partly into the air without immediate decomposition. The oxidation of methane to formaldehyde during the combustion has been shown to be without doubt by Bone and Wheeler if the products of reaction are continuously removed from the system and naturally such a condition occurs in the fumigation process we are dealing with.

The incomplete combustion of ethane was investigated first by E. von Meyer (*J. prakt. Chem.*, 1874, (2), **10**, 308-18), and then into details by Bone and coworkers (*J. Chem. Soc.*, 1904, **85**, 693 and other papers). When oxidation of ethane and oxygen was carried out under reduced pressure by continuously circulating the gases through a tube kept at 400° to 500°, the gaseous products included carbon monoxide, carbon dioxide, hydrogen, ethy-

lene, oxygen and ethane. Both formaldehyde and acetaldehyde were detected in water through which the gases were passed immediately after leaving the heated tube. There was also some evidence of the intermediate formation of formic acid. Marks (*Brit. pat.*, 238, 938; *Acc.*, Aug. 26, 1925) found that formaldehyde could be produced with greater ease by the partial oxidation of ethane than was the case with methane. He passed a mixture containing one volume of ethane and two volumes of air at a rate of 27 litres per hour through a silica tube heated to 700° to 710° over a length of 2 feet. The exit gases were divided into two streams so that 10 volumes of exit gas were re-circulated with each volume of fresh mixture. The liquid condensed in the cooled receiver consisted of an aqueous solution of formaldehyde. About one-sixth of it, acetaldehyde was also produced. The slow combustion of ethane, as shown by Bone (*British Assoc. Reports*, 1910, p. 491; Bone and Stockings, *J. Chem., Soc.*, 1904, 85, 693), appears to proceed as follows:


C_2H_6
Ethane
decomposition
at 500° c.
$C_2H_4+H_2$
ethylene
$C_2H_2+H_2$
acetylene
decomposition
CH_3CH_2OH
ethyl alcohol
oxidation
$CH_3.CH(OH)_2$
oxidation
(Hypothetical)
decomposition
decomposition
at 300°–400°
CH_4+CO
methane
CH_3CHO+H_2O
acetaldehyde
decomposition above 400°
$H_2+CO+CO_2+CH_4+C$
oxidation
CH_3COOH
acetic acid
oxidation
COOH
CH_2OH
glycollic acid
decomposition
$HCHO+CO+H_2O$
formaldehyde
decomposition
$CO+H_2$
oxidation
HCOOH
formic acid
decomposition
$CO+H_2O$
oxidation
$CO(OH)_2$
carbonic acid
CO_2+H_2O
oxidation

Of all these products, we are concerned here with the formation of formaldehyde, formic acid, acetaldehyde and acetic acid. During fumigation, these products diffuse out into the surroundings along with smoke and other substances. We have also seen that ethane decomposes at 500° to give ethylene and finally acetylene. These substances also undergo partial oxidations during the course of subsequent combustion in the fumigation process and a number of products according to the following scheme are given out. (Bone and Wheeler, *J. Chem. Soc.*, 1904, *85*, 1637).

$$\underset{\text{ethylene}}{CH_2 : CH_2} \rightarrow \underset{\text{vinyl alcohol}}{CH_2 : CHOH} \rightarrow \underset{\text{(hypothe.)}}{CHOH : CHOH} \rightarrow \underset{\text{formaldehyde}}{2HCHO}$$

$$\rightarrow \underset{\text{formic acid}}{H.COOH} \rightarrow \underset{\text{carbonic acid}}{CO(OH)_2} \rightarrow CO_2 + H_2O$$

Formaldehyde is similarly generated from acetylene according to the following scheme:

$$\underset{\text{acetylene}}{CH : CH} \rightarrow C(OH) : C(OH) \rightarrow \underset{\text{formaldehyde}}{HCHO} + CO$$

and this formaldehyde is finally oxidised to formic acid, and then to carbon dioxide and water as described above. (Bone and Andrew, *J. Chem. Soc.*, 1905, *87*, 1232).

Bone and Drugman (*ibid.* 1906, **86**, 660) investigated the combustion of propane with oxygen by exploding two volumes of the hydrocarbon with three of oxygen in a closed tube. They found as products of the reaction: aldehydes, carbon monoxide, carbon dioxide, methane, unsaturated hydrocarbons (including acetylene) and hydrogen. These authors also found similar products from the oxidation of butane, which gives ethylene besides other substances. The aldehydes formed have not been identified. For detailed description, readers are referred to a summarising paper by G. Egloff and R. E. Schaad on 'The Oxidation of the Gaseous Paraffin Hydrocarbons' in the *Chemical Reviews* (1929, **9**, 91-141).

Photochemical Processes

It is difficult to discuss the photochemical changes to which the products of fumigation are subjected. The tradition is to perform Agnihotra in the morning after sunrise and in the evening before sunset, and the importance of sunlight has always been emphasised for health and prosperity by occidentalists also. Strong sunlight, besides being a most efficient germicide, is also an effective agency to bring out a number of chemical changes

especially in the ultraviolet and other short wavelength regions. Photochemical decompositions, oxidations, reductions, polymerisations and phototropic changes are very well known, and our fumigation products are subjected to all these changes. Alcoholic and aldehydic compounds are oxidised, phenolic compounds polymerise, hydrocarbons get oxidised and polymerised both, and complex compounds are decomposed to simpler products. To some extent, even carbon dioxide is reduced to formaldehyde, the reaction being as follows :

$$CO_2 + H_2O + 112{,}000 \text{ cal.} = H.CHO + O_2$$

the photochemical energy for the reaction corresponding to the ultraviolet wavelength 2550Å. The H - OH link of the moisture content of the atmosphere is also broken up by the absorption of active rays, and the free radicals H and OH bring about a number of changes, sometimes acting catalytically and sometimes actually taking part into the reaction. The amount of formaldehyde present in the atmosphere is partly due to the photochemical process also, even when there are some wavelengths responsible for its decomposition. Most of the formaldehyde is due to the diffusion of the decom-

position products from the lower strata. The influence of sunlight is ultimately to oxidise all the products to carbon dioxide and water and thus bringing out the complete oxidation.

Dhar and Atma Ram have shown that in the case of many substances as acetic acid, glycerol, acetone etc., formaldehyde is one of the direct products of photo-oxidation. They have also shown that the energy rich carbon dioxide produced in the photo-oxidation of many organic substances combines with the photolysed water to give formaldehyde (*J. Indian Chem. Soc.*, 1933, 10, 161; 287).

SUMMARY

From all that has been said in the foregoing pages, it will be seen that the fumigation process is one which involves a number of complications. It is essentially a slow combustion process and the products given out may be summarised below:

(i) The temperature being sufficiently high and varying between wide limits, the substances with boiling points between 200°-350° vaporise out and diffuse. This class includes various oils from sandal wood, agar, sesame, deodar, various terpenes, and aromatic compounds of high boiling points.

(ii) In the vicinity of low temperatures also, a number of volatile substances diffuse out along with steam ('steam-distilled') which is the product of combustion of celluloses and other allied bodies. The substances of this class are thymol, eugenol, aceteugenol, carvacrol, coumarins, pinene, borneol, terpineol, cineol, a number of esters and aldehydic bodies.

(iii) As a result of the distillation of wood, substances like acetic acid, methyl alcohol, methane, acetone, acetaldehyde and naphthalene bodies are given out.

(iv) Resinous substances on distillation give formaldehyde, turpentine and tar products.

(v) Some of the aromatic compounds and lower fatty acids are mechanically carried over by smoke which acts as a colloidal vehicle.

(vi) The combustion of fatty substances gives a number of hydrocarbons. From glycerol portion are obtained acetone bodies, pyruvic aldehyde, glycol aldehyde, glyoxal etc. Fatty acids are reduced to a number of hydrocarbons and lower fatty acids which volatilise easily. The products are methane, ethane, propane, butane, ethylene, butadiene, acrylic acid, and acetic acid.

(vii) Unsaturated fatty acids give on oxida-

tion at the double bond higher fatty aldehydes as octylic, nonylic and even valeric and capronic aldehydes.

(viii) The hydrocarbons produced during the above reactions undergo again slow combustion (which includes oxidation and decomposition processes), and as a result, methyl and ethyl alcohols, formaldehyde and acetaldehyde, formic and acetic acids, and some unidentified aldehydes are also formed.

(ix) When all these volatile substances have diffused into the atmosphere, they are subjected to the photochemical reaction of sunlight and undergo various modifications.

(x) The ultimate oxidation of all these products is to carbon dioxide and water.

CHAPTER IV

FUMIGATION AND DISINFECTION

In the last chapter, we have seen that a number of aldehydic, phenolic and acid volatile substances are given out during the course of fumigation. It is beyond the scope of the present monograph to enter into the details of chemical bacteriology and to discuss various biological aspects to which these results can be profitably utilised. Purification of air is one of the specified motives with which the Agnihotra is performed. By purification, it is understood that air would be free from its foul constituents, and injurious bacteria, and also get contaminated with fine aroma. Nature has already provided us with sufficient means by which purification is going on in our surroundings by physical agencies, the sun, the heat and the flora. Agnihotra is a representative imitation of what is going on in the universe and it is not a far-fetched metaphor if our ancestors drew its analogy with the Cosmic *Yajña*.

In tropics, the energy derived from the sun

in form of heat and light both, is utilised for the disinfection process in nature. In spite of the fact that the upper atmosphere is rich in ozone and therefore, absorbs many of the actinic wavelengths from the sunlight as it falls to the earth surface, it is very seldom that all these radiations get absorbed and our light remains pretty rich in ultraviolet radiations. Even the wavelengths upto 4500Å have been found efficacious to weaken the activity of many bacteria. Some wavelengths directly injure these harmful bodies, while the others synthesise such chemical products in atmosphere, that in their presence, bacteria find it difficult to survive, as ozone, formaldehyde and hydrogen peroxide. In summers, when the temperature of the atmosphere in tropics rises as high as 60°, many of the bacteria, pathogenic and non-pathogenic both, are either completely destroyed or are rendered inactive.

Vegetation purifies air in two ways. Firstly, by assimilating carbon dioxide and giving out pure oxygen, it keeps the atmosphere fit for our use, and secondly, flowers always diffuse out their essential constituents to the surroundings which also partly help in the bacterial disinfection. The presence of aromatic compounds in plants and flowers is very significant for the plant life itself, and in this con-

nection, the following passage from R. W. Thatcher's "The Chemistry of Plant Life" (1921) will be interesting :

"It is evident that those aromatic compounds which occur as normal secretions of plants and which give to the plants, their characteristic odours may act either as an attraction to animals which might utilise the plants as food and serve to distribute the seed forms, or as a repellent to prevent the too rapid destruction of the leaves, stems, or seeds of certain species of plants whose slow growing habits require the long continued growth of these portions of the plant for the perpetuation of the species. The presence of these compounds in larger proportions in those species of conifers, etc., which grow in tropical regions, in competition with other rapid growing vegetation, suggests the latter possibility. It must be admitted, however, that their presence in such cases may be the result of climatic conditions as indicated by the fact that most spice plants are tropical in habit, rather than the result of their protective influence in the struggle for survival during past ages.

"Many of the oils and resins which are secreted as the result of injury by diseases or wounds have marked antiseptic properties and undoubtedly serve

to prevent the entrance into the injured tissue of the destructive organisms." (p. 150).

In view of all this, it is very well seen that aromatic constituents are useful for the plant life and offer protection from the destructive agencies. Air in which phenolic vapours have been diffused in minute traces will be thus healthy for the plant growth. The disinfection of air is not only necessary for animal life but for plants also though in both the cases, the pathogenic bacteria responsible for diseases are quite different. (See also "The Scent of Flowers and Leaves" by F.A. Hampton, p. 32).

Formaldehyde Disinfection

In the last chapter, we have seen that formaldehyde is formed as a result of various reactions. The partial oxidation of hydrocarbons and the decomposition of many complex organic substances during the fumigation process are responsible for its production in sufficient concentrations, though the quantitative figures can not be given here. Loew and Fischer, in 1886, discovered that it possessed powerful antiseptic properties. It saves many substances from putrefaction. Cambier and Brochet (*Compt. rend.*, **119**, 607) showed that the vapour of formaldehyde effects the complete steri-

lisation of household dust. Slater and Rideal (*Lancet*, April 21, 1894) examined the action of vapour evolved at 19°C. from a 40 per cent solution by exposing to it glass slips of dry bouillon cultures under a bell jar. *B. typhosus*, *B. coli*, *M. prodigiosus* and *Sp. cholerae* were killed in less than ten minutes; *S. pyogenes aureus* in twenty; *B. pyocyaneus* in thirty minutes. In some experiments, threads soaked in various cultures were exposed at some distance from the source of formaldehyde vapours and marked effects were observed. The threads after disinfection in all cases produced more scanty cultures which grew more slowly. Some of those impregnated with *B. typhosus* and *B. coli* were sterile.

The germicidal action of fomaldehyde is only affective in presence of moisture vapour, and it will be interesting to note that in the fumigation process we are considering, formaldehyde is always produced in accompaniment with water vapour in large amounts and therefore, it acts as a powerful disinfectant. Nowadays, a number of mechanical appliances are available to volatilise paraformaldehyde (polymerised formaldehyde) and to produce formaldehyde sprays for disinfecting walls, ceilings and floors.

We have also seen that during the fumigation hydrocarbons are converted to methyl alcohol which is subsequently oxidised to formaldehyde. On the very principle, many lamps for aerial disinfection have been proposed where formaldehyde is generated by the combustion of a mixture of methyl alcohol vapours and air over red hot platinum. Platinum surface is to give formaldehyde catalytically in almost quantitative proportions, while for ordinary daily infection, the minute quantity of formaldehyde generated during fumigation of substances as described, is also sufficient. Formaldehyde lamps have been devised by Tollens, Bartel, Robinson, Trillat, Broche, Schweinertz and Dieudonné. Paraformaldehyde, compressed into tablets, has been used by the Formalin Hygienic Company in their Alformant or "Schering" lamp. By exposing to the vapours, Dr. Kenwood succeeded in sterilising swabs infected with *B. diphtheriæ* when exposed to the formaldehyde vapours from this lamp. Vapours were efficacious in killing under various conditions the following bacteria: *B. coli communis*, *Staph. pyog. aur.*, *B. typhosus*, *B. diphtheriæ*, *B. anthracis* and *B. subtilis* (PUBLIC HEALTH, Nov. 1897). The necessary condition of moisture in both these lamps, (as in our fumigation process

also) is supplied by the combustion of spirit used for heating the solid paraform and in some cases steam is obtained by evaporating water in an attached appliance. (S. Rideal and E. Rideal, *Chemical Disinfection and Sterilisation*, 1921, p. 18).

Other aldehydes—The higher aldehydes are certainly not so active germicides as formaldehyde but many antiseptic solutions have been prepared from acetaldehyde and its polymer. Acetaldehyde in sufficient concentrations is germicidal to anaerobic organisms. Acrolein, although, toxic, appears to possess no germicidal activity.

Aliphatic Acids as Disinfectants

Formic acid—We have seen that in the course of fumigation, the product next to formaldehyde is formic acid in oxidation of hydrocarbons. This substance in its constitution still retains the aldehydic grouping and therefore, is a very powerful disinfectant. It is doubtful whether in its disinfectant properties, it always exceeds acetic acid or not. Kitasato and Horrocks have given the following figures in nutrient media for both the acids. (Amounts of acids given in per cent):

Acid	Growth	Growth restrained	No growth
With B. typhosus			
Formic acid ..	0.22	0.278	0.356
Acetic acid ..	0.2	0.225	0.3
With Sp. choleræ			
Formic acid ..	0.11	0.167	0.22
Acetic acid ..	0.1	0.153	0.2

But in water and organic solutions, formic acid appears to be a better disinfectant for *B. typhosus* as has been observed by Rideal. Though mostly used for fruit preservations, formic acid is also a good disinfectant for air in vapour conditions.

Acetic acid—It is one of the very ancient preservatives, and was used mixed with essential oils (*aromatic vinegar*). Rideals have observed that *B. coli* is killed by 5 per cent acetic acid in five minutes. Acetic acid escaping along with smoke is also a very good disinfectant for rooms, and in this form it also protects plant incisions from the attack of destructive organisms. Smoke contains formic acid also.

Pyroligneous acid—This acid is generated during the combustion of wood, and it owes its antiseptic

power chiefly to the presence of formaldehyde and creosote.

Propionic acid—It has been found half so efficacious as formic acid as a disinfectant, and the killing effect on even a high resistant bacteria like *B. subtilis* has been observed by Duggan (*Amer. Chem. J.*, 7, 62).

Valeric acid—It is a feeble antiseptic and along with creosote, it has been introduced under the name *geosote*.

Pyruvic aldehyde and pyruvic acids are also slightly germicidal.

Alcohols as Disinfectants

It has been seen that many alcoholic substances result during the combustion of unsaturated and saturated fatty acids in the intermediary stages, but they are then further decomposed or oxidised. Ethyl and methyl alcohols by themselves are not antiseptic, and possess only a low disinfecting power. But with the increase in the number of carbon atoms in a particular alcohol series, butyl, amyl and allyl alcohols are fairly strong disinfectants. Even propyl alcohol has antiseptic properties.

Dihydric and trihydric alcohols like glycol and

glycerol are not disinfectants. Esters of lower fatty acids and ketones exert little if any germicidal action.

Aromatic Hydrocarbons and Phenols

Aromatic hydrocarbons are ordinarily no good disinfectants, but naphthalene is known to be a good insecticide. Camphor has some utility as a disinfectant, though substances like it may be more useful in masking foul odours.

A number of phenolic compounds have been described before which are given out in the process of fumigation. The ordinary carbolic acid phenol and cresols are very powerful disinfectants. It is difficult to say that any carbolic acid is generated in fumigation, and the evidence for cresols is not much convincing. The phenols obtained are cuminol, eugenol, carvacrol, thymol, anethol and safrol, and other essential constituents. Some of the wood resins yield substances like guaiacol (methoxy phenol) which have undoubtedly marked antiseptic properties. In fact, wood creosote owes its property as a disinfectant to this substance to some extent.

The class of phenols we are concerned here

belong to the essential oil or perfume groups. All of them have a limited sanitary value, but none the less, they all act as disinfectants. They are only sparingly soluble in water, and so their solutions cannot have wide applications, but if volatilised, as is done in the process of fumigation, they exhibit better results. All of them are sweet smelling and non-drastic and this adds to their advantage for ordinary use.

Thymol solutions (0.3%) are known to arrest fermentation and putrefaction. Peppermint, containing menthol and menthene, was well known and included in a number of 'plague-water' recipes. Terpin hydrate from turpentine (a constituent of deodār wood) arrests the growth of tubercle bacilli in 0.25 per cent strength while terpineol has been stated to kill anthrax and staphylococci in solutions of suitable concentrations. Camphor, in the form of fumes, has a very marked antiseptic action. Though it is valued as a personal prophylactic and at ordinary temperature, it does not give out sufficient vapour to be used as a disinfectant for air, if yet be volatilised above 100° or so, it is more efficacious. The camphor oil is very markedly germicidal. Cineol also possesses feeble antiseptic properties.

Perfumes and their Disinfectant Power

No subject is perhaps so uncertain as the relation of perfumes as such with their usefulness as germicides or disinfectants. The physiological utility of the odorous principle has not yet been satisfactorily worked out. It is difficult to say why one likes a particular odour. Is it simply a matter of aesthetic significance or something more even?

Since the days of Schönbein (1840), it has been emphasised that essential oils owe their disinfectant power only to a secondary process. They are slowly oxidised in presence of air and moisture, whereby ozone or hydrogen peroxide is produced, and as long as air and oil are present, the ozone or hydrogen peroxide is continuously generated and absorbed. These oxidising substances are then responsible for the main disinfection.

Heinz has given in his "*Handbuch der Pathologie*" the following antiseptic concentrations of some essential oils :

Oil	Organism	Antiseptic dilution
Menthol ..	B. diphtheriæ	1 : 16,000
	Staphylococcus	1 : 6,000
	B. typhosus	1 : 8,000
Camphor ..	Staphylococcus	1 : 600
	B. diphtheriæ	1 : 30,000
Turpentine	Staphylococcus	1 : 15,000

Since very ancient times, people have been believing in the antiseptic value of perfumes. Criton, Hippocrates and others have classified perfumes amongst medicines, especially for the diseases of nervous kind. Pliny has also attributed therapeutic properties to various aromatic substances. Ungerer was the first modern observer to call attention to the antiseptic qualities of perfumes in general. It was his belief that the cause of so few cases of tuberculosis in the flower growing districts of France was the fact that the atmosphere there was so full of the germ killing odours of flowers. He also noticed that those people who worked in the perfume laboratories were free from disease of respiratory organs and those with bronchial affections often unconsciously cured themselves in the atmosphere filled with the odours of volatile oils.

Later, a number of other scientific investigators

adopted also the same view and they recognised the germicidal properties of many essential oils. Chief workers amongst these were M. Chamberland of the Pasteur Institute, Paris; Mm. Cadeac, Meunier, Smetchensko and M. Charrin.

G. W. Askinson has given an interesting account of some observations of this nature which we shall quote here: Tests were first made upon the germs of glanders and yellow fever, and these germs were easily killed by the odours of essential oils. Later experiments were made with a number of oils under ordinary temperature. The oils found most effective were Ceylon Cinnamon, Chinese Cinnamon, Clove, Origanum, French Geranium, Algerian Geranium, Indian Verbena, Lavender, Patchouly, Angelica, Juniper, Sandal, Bitter Orange, Cedar, Thyme, Lemon, Peppermint, French Verbena, Pine, Wormwood and Cubeb as well as extracts of Jasmine and Tuberose.

In order to test the action of the oils upon germs as usually encountered in air, on walls, or on the human body, the experimental tests were made as follows:

The end of a fine platinum wire was covered with gelatin containing the culture to be tried. This wire was fixed into a cork and the cork put into the

end of a test tube in the bottom of which was some of the oil being tested. At the end of a given time sterilised gelatin was pricked by the germ bearing wire and then heated to bring about growth.

The bacteria tested in this way were: *Golden Staphylococcus*, *Streptococcus*, *Coli bacilli*, *Tetrageni*, and *Bacilli virgule*. Of the five it was found that the *Golden Staphylococci* had the greatest power of resistance.

It was ascertained that the germs still remained alive after being exposed to the vapours of the following oils for 72 hours: Angelica, Patchouly, Lemon, Bitter Orange, Juniper, and Sandal; but were killed in that time when exposed to French Geranium, Peppermint, Origanum, Pine and Thyme.

Sixty hours time was long enough to kill the germs by Wormwood, Cedar, Cubeb, Algerian Geranium; and 48 hours was sufficient to sterilise by the volatilisation from Ceylon and Chinese Cinnamon, Clove, Lavender, French and Indian Verbena, extract of Jasmine and Tuberose.

Results were more or less contradictory when tests were made for 48 hours or less. Sometimes germs seemed to be dead after 24 hours and in other cases the same germs were alive after 36 hours of

exposure.

Further experiments showed that the *Tetragene bacilli* were killed in 48 hours by all the oils except Bitter Orange, Peppermint and Cubeb; *Streptococcus* was killed in 48 hours by all the oils except Bitter Orange; *Virgule bacillus* was made innocuous by all the oils after only 4 hours; *Coli bacilli* could not resist for 24 hours the vapours of Ceylon Cinnamon, Clove, French Verbena, and Tuberose. The *Golden Staphylococci* were also killed in 24 hours by the evaporations from Ceylon and Chinese Cinnamon, Lavender, Clove, Verbena, Jasmine and Tuberose.

Continued experiments carried to very fine extremes went to prove that many of the bacteria were killed in less than an hour by the evaporations from the oils mentioned, and in some instances, a few minutes of exposure to these oils was sufficient to bring about the death.

The importance of these investigations can hardly be exaggerated, for especially in times of epidemic, the value of perfumes cannot be discounted, and even under ordinary circumstances, it is known that the air is filled with germs of all kinds, which are best combated by such pleasant germicides as our perfumes.

The opinion to the contrary which is sometimes expressed, is generally based upon a misunderstanding of the subject or is the result of imagination. It is true that flowers, if left in a closed sleeping apartment all night, will sometimes cause headache and sickness, but this proceeds not from the diffusion of the aroma, but from the carbonic acid they evolve during the night. If perfume extracted from these flowers were left open in the same circumstances, no evil effect would arise from it (p. 235).

The following antiseptic values of a number of essential oils are given in the *Perfumery and Essential Oil Record*, July, 1924; the antiseptic value of carbolic acid being taken as unity.

Natural oils		*Synthetic oils*	
Thyme	12.2	Citral	18.8
Verbena	9.2	Eugenol (clove)	14.4
Clove	8.5	Geraniol (rose)	11.5
Cinnamon	7.8	Methyl anthranilate	2.8
Rose	7.0		
Rue	6.4		
Rosemary	5.2		
Lavender	4.4		
Ylang-ylang	2.8		

The following remarks of Hampton regarding the antiseptic value of perfumes will be interesting :

"Their antiseptic value faintly justified the use of Rue and Rosemary at the Old Bailey as protection against jail fever, and of the cinnamon and camphor in the doctor's gold-headed cane. "Four Thieves' Vinegar" was an infusion of aromatic herbs and garlic used by four robbers to protect themselves while they stripped the dead during the plague year at Marseilles in 1722.........

"It may well be that these prophylactics had a real value, not in destroying germs, but in keeping off the bugs and lice that carried them. The black plague and the purple fever have withdrawn to less civilised countries than ours, together with their attendant vermin and the sprigs of Rue and Rosemary only persist at the Old Bailey out of our pleasant respect for old tradition. But the vermin reappeared with the relapse of civilisation in the Great War, and were proven carriers of trench fever; and once again, the essential oils were used to ward them off. The writer remembers well, one damp December night during the war, stumbling across a powerful scent of mixed aromatics in Sanctuary Wood, and finally tracing it to a yeoman who had protected himself against lice by saturating his clothes with a mixture of aniseed and sassafras." (*The Scent of Flowers and Leaves*, 1925, p. 34).

We have also repeatedly experienced that during malaria, cholera, plague and other epidemics, the performance of Agnihotra on a large scale in numerous quarters of the town has been very efficacious.

Effect on Non-Bacterial Parasites

We shall conclude our subject of disinfectants by referring to the effect of various products of fumigation on non-bacterial parasites which happen to spread a number of diseases and are always a source of great trouble. To this class belong bodies like Pediculi or lice which cause the disease phthiriasis, scabies or the itch causing insect, ringworms, various flies, mites, fleas and numerous worms. It is difficult to deal with them because many agencies which might be used to combat against them are also harmful to the higher animals. To the ordinary reagents, they are resisting. Ordinarily body is preserved against their action by application of various ointments. However, there are many volatile substances whose odour is very obnoxious to insects, and therefore, during fumigation, there is a likelihood of their being driven away. We shall call such substances *insectifuges* rather than insecticides. Camphor and many essential oils can, moreover, actually kill insects. The vermifuge action is one reason for the adoption of perfumes and incense.

The following account from S. Rideal and E. Rideal's *Chemical Disinfection and Sterilization*

(1921) is given here: "The trenches in warfare often become infested with body vermin. Belts are manufactured containing substances of strong odour to be worn near the skin and are said to keep these pests away from the person. Essential oils drive lice away, but the latter are only killed by such substances if they remain a long time in the vapour of the oils, and the eggs are not killed at all. Winter green oil appears to be the most active of the class; then follow camphor, bergamot, fennel, eucalyptus and rosemary." (*Chem. and Drug.*, June 12, 1915, 34; Nov. 27, 1915). Dr. A. Zucker (*Centr. Bakt.*, 1915) has shown that lice are driven away by essential oils, menthol, turpentine oil, Peru balsam, solution of carbolic acid, precipitated sulphur, infusion of tobacco, black pepper and fatty acids and are rendered inactive by formaldehyde, acetylene and illuminating gas.

It is our experience that pests, flies, mosquitoes, and similar worms are driven off by ordinary smoke produced by burning resinous substances. The fumigation process which we have described gives out many of the products investigated as vermicide by Zucker and therefore, it can also be recommended instead.

Thus the products given out as fumes during

the performance of Agnihotra are (i) bactericidal, (ii) foul odour masking, and (iii) vermifugal.

The Role of Carbon Dioxide

The ultimate product of combustion is carbon dioxide. The main significance of the fumigation process lies in the generation of intermediate products which have been discussed before. We humans are unable to assimilate carbon dioxide directly while plants under the action of sunlight convert it to various products of our use. There is sometimes a prejudice in certain quarters against the fumigation processes simply on account of the fact that carbon dioxide is ultimately produced in such reactions. Carbon dioxide, though directly is not a supporter of life, is, however, not a poison. Our mineral waters owe their taste to it. It is the ultimate product of so many other processes against which there is hardly any prejudice, for example the combustion of fuel for our household purposes, for running our machinery and our own internal physiological combustion engine. During fumigation, it acts as a mechanical vehicle in transporting many antiseptic and vermifuge products to distances and in the spread of the fragrant aroma in the surroundings.

APPENDIX I

THE PERFUMES USED FOR FUMIGATION

G. W. Askinson, the author of *Perfumes and Cosmetics* (1922) has divided the perfumes used for fumigation into two groups: (i) those which develop their fragrance on being burnt, and (ii) those which do so on being merely heated. The former group includes pastils and ribbons and the latter, fumigating powders and waters.

Fumigating pastils—Räucherkerzen

Pastils consist in the main of charcoal to which enough saltpetre is added to make the lighted mass glow continuously and leave a pure white ash. To this mass are added various aromatic substances which are gradually volatilised by the heat and fill the surrounding air with their perfume. For ordinary pastils, finally rasped fragrant woods such as cedar and santal are frequently employed. During the slow combustion, however, the wood gives off products of pungent and disagreeable odour such as acetic acid and empyreumatic pro-

ducts which lessen the fragrance. Fine pastils are composed of resins and essential oils and are usually formed into cones 2/5 to 4/5 of an inch high, by being pressed in metal moulds. (p. 226).

The manufacture of fumigating pastils consists of powdering and mixing of solid ingredients, and essential oils together with enough mucilage of acacia to form a plastic mass, and finally, kneading and drying to have firm consistence. A few of the recipes are as follows :

I. *Pastilles Orientales* :

Charcoal	1.5 lb.	Benzoin	0.5 lb.
Saltpetre	3.5 oz.	Amber	3.5 oz.
	Tolu balsam	2.75 oz.	

II. *Pastilles du Sérail* :

Charcoal	1.5 lb.	Sandal wood	5.5 oz.
Saltpetre	3.5 lb.	(Opium)	1.75 oz.
Benzoin	0.5 lb.	Tolu balsam	2.75 oz.

Opium may be entirely omitted.

III. *Baguettes Encensoires* (Fumigating Pencils) :

Benzoin	14 oz.	Olibanum	5.5 oz.
Charcoal	1.75 oz.	Civet	75 grains
Peru balsam	1 oz.	Oil of bergamot	1 oz.
Storax	2 oz.	Oil of orange peel	1 oz.
Shellac	3.5 oz.	Oil of santal	0.75 oz.

Such a pencil gives off the aromatic products when lightly passed over a hot surface.

IV. *Pastilles Odorferantes*:

Charcoal	2 lb.	Vanilla	7 oz.
Saltpetre	3.5 oz.	Vetiver root	7 oz.
Benzoin	1.5 lb.	Cinnamon	3.5 oz.
Cloves	7 oz.	Oil of neroli	150 grains
Tolu balsam	7 oz.	Oil of santal	3/4 oz.

V. *Poudre d'Encens* (Incense powder):

Benzoin	0.5 lb.	Saltpetre	3.5 oz.
Cascarilla	0.5 lb.	Vetiver root	5.5 oz.
Musk	15 grains	Olibanum	1 lb.
Santal wood	1 lb.	Cinnamon	5.5 oz.

Fumigating Papers and Wicks

Fumigating papers are strips impregnated with substances which become fragrant on being heated. These papers are of two kinds, firstly, those meant to be burnt, and secondly, those meant to be used repeatedly. The former before being treated with aromatics, are dipped into saltpetre solution; the latter in order to render them incombustible, are first dipped into a hot alum solution so that they are only charred by a strong heat, but not entirely consumed. An excellent paper is made according to the following formula as given by Askinson (p. 229):

A. *Inflammable fumigating paper*:

Benzoin	5.5 oz.	Oil of lemon grass	150 gr.
Santal wood	3.5 oz.	Essence of vetiver	1.75 oz.
Olibanum	3.5 oz.	Alcohol	1 qt.

The paper gives out pleasant odour with sparks on touching with a red hot substance.

B. *Non-inflammable fumigating paper*:

The paper is first dipped in hot solution of alum, dried and then saturated with the following mixture:

Benzoin	7 oz.	Tincture of tonka	7 oz.
Tolu balsam	7 oz.	Essence of vetiver	7 oz.

Alcohol 20 fl. oz.

C. *Fumigating Ribbons*:

About half an inch cotton tape is taken and saturated with nitre. It is then allowed to dry up and saturated with the following tincture:

Benzoin	1 oz.	Tolu balsam	2 drachms
Orris root	1 oz.	Musk	10 grains
Myrrh	2 drachms	Rectified spirit	10 oz.

It is macerated for a week, filtered and 10 minims of attar added.

Fumigating Perfumes:

These are used for quickly putting down bad odours in the sick room. They are decidedly antiseptic and fulfil their purpose admirably. (Henley's *Twentieth Century Book of Recipes, Formulas and Processes*, 1916, p. 366). A piece of blotting paper

is saturated with potassium nitrate solution, then dried up and again saturated with the following solutions:

Siam benzoin	1 oz.	Mastic	2 scruples
Storax	2 dr.	Cascarilla	2 dr.
Olibanum	2 scruples	Vanilla	1 dr.
	Rectified spirit 8 oz.		

Besides these forms of fumigants, there are fumigating waters consisting of strong solutions of various aromatic substances in alcohol, a few drops of which suffice, if evaporated on a warm plate, to perfume a large room. Sometimes, when mixed with glacial acetic acid, fumigating vinegar is obtained which is remarkably efficient in expelling foul odours.

It will not be difficult to see the close analogy that exists between the oriental fumigation process which we have described and the modern fumigants used for various purposes. The nature of substances used and the conditions for fumigation are almost the same. The Indian fumigation process has attained the ecclesiastical value and is, therefore, rich in many details. It is very convenient as a daily usage.

APPENDIX II

AROMATIC VEGETABLE SUBSTANCES

1. Allspice, or pimenta: It consists of fruit berries, black in colour indigenous to Central America and Antilles.

2. Anise: It is a plant of the order of Umbelliferæ. The seeds contain about 3 per cent of a very aromatic essential oil.

3. Balm, Melissa officinalis: A herbaceous plant with beautiful flowers which on distillation give very sweet smelling oil.

4. Bay, Sweet, Laurus nobilis: The fruits of the bay tree contain much essential oil.

5. Bay from West Indies, Myrcia acris, possesses a very aromatic odour resembling that of allspice. The oil is obtained from leaves.

6. Benzoin: This gum resin, which possesses a pleasant vanilla like odour, comes from a tree belonging to the order of Styracacæ, the Styrax Benzoin, indigenous to Tropical Asia, especially Siam and Sumatra. It contains benzoic and cinnamic acids, and emits on heating vapours of acrid

taste and aromatic odour.

7. Bergamot, Citrus Bergamia: It is the fruit of the order of Aurantiaceæ, cultivated in Calabria, contains a very fragrant oil. The odour is due to linalyl acetate and allied esters.

8. Bitter Almond, amygdala amara: The oil obtained from the bitter almonds has an aromatic odour of benzaldehyde.

9. Cajuput Leaves: The leaves of Melaleuca Cajuputi found in Indian and Malaya Archipelago have an aromatic odour resembling cardamoms.

10. Camphor wood: The wood of camphor tree native of China and Japan, is exceedingly rich in essential oil, and the strong scented camphor.

11. Caraway seed: The plant Carum Carvi is largely cultivated in Germany, the seeds of which contain 5 per cent of an essential oil.

12. Cascarilla Bark: A bark of the West Indian tree, Croton Eluteria, native of Bahamas. On heating, it gives out a very agreeable odour. (2.5 per cent oil)

13. Cedar wood: The wood is derived from the Virginian juniper tree, the chips of which are used for extraction of the essential oil. Long uniform shavings of this wood are used for fumigation. (0.7 to 1 per cent oil)

14. Cinnamon: It consists of the barks of the young twigs of the cinnamon tree, indigenous to Ceylon. It has got a pronounced characteristic odour. Chinese cinnamon or cassia consists of the bark of cassia tree. This is grayish brown and has the general properties of true cinnamon though it has a less fine odour. Saigon cinnamon, from Cochin China is very rich in oil. Oil is also obtained from the cinnamon flowers, the unripe fruits in fact.

15. Citron, Fructus citri: The tree citrus medica, indigenous in Northern India and also cultivated around the Mediterranean is cultivated both for the acid juice of the fruits and for their fragrant rinds. These rinds are sold under the name of citron peel. The fresh flowers of the citron tree contain a very aromatic essential oil.

16. Citronella, Andropogon Nardus: This grass is native of Northern India and is largely cultivated in Ceylon. Its odour is somewhat similar to that of the Indian lemon grass. There are many sources of the Indian grass oil, e.g., Andropogon citratus DC, Andropogon laniger Desf., Andropogon muricatus Retz. (source of oil of vetiver). Andropogon nardus L. (source of oil of citronella) and Andropogon Schoenanthus L. (Ginger grass).

17. Clove, Caryophylli: The tree is found native at Moluccas, and is largely cultivated at Zanzibar and Pemba. The spice consists of the closed buds, which contain 18 per cent of the essential oil.

18. Dill, Semen Anethi: It is indigenous to the Mediterranean region and Southern Russia, and the plant contains in all parts, particularly seeds, an oil of characteristic odour.

19. Fennel, Fœniculum: The plant is largely cultivated in Europe and contains an essential oil in all its parts, especially in seeds.

20. Geranium, Pelargonium roseum: A plant indigenous to South Africa, containing essential oil in leaves, the odour of which resembles that of rose oil.

21. Hedyosmum: The bushes of this genus contain flowers of magnificent intoxicating odour. Only accessible to English perfumers.

22. Heliotrope: The flowers of this plant flourishing in temperate and tropical countries possesses a pleasant odour resembling piperonal.

23. Lavender: Flourishes throughout Central Europe.

24. Lemon: The peel contains an essential oil resembling that of citrons in odour.

25. Mace: This substance is the dried arillus covering the fruits of nutmegs. The tree is indigenous to the Indian Archipelago islands. The orange yellow coloured pieces of mace have a strong odour and are very oily.

26. Marjoram: The plant Origanum Majorana possesses in all parts a strong odour due to an essential oil.

27. Mint, Mentha: All the mints, peppermint, spearmint, crispmint, have a pleasant odour.

28. Myrrh: This gum-resin has been long known in the East, especially on the borderlands of the Red Sea. The gum exudes spontaneously from the trunk and possesses a pleasant odour.

29. Myrtle leaves: The leaves of this Southern European plant diffuse a pleasant odour.

30. Nutmeg, Myristica: The nuts contain a faint odour and the oil is used in perfumery.

31. Olibanum: This gum-resin known from ancient times as incense for religious purposes, comes from East African trees. It is used for pastils and fumigating powders.

32. Orange peel, Cortex Aurantii: The oily rinds of commerce occur in dried form. Peels are also used.

33. Orris root, Radix Iridis florentinæ: It

grows wild in Italy. The fresh root has a disagreeable sharp odour but the dried one has the odour resembling that of violet.

34. Patchouly: The herb is indigenous to the East Indies, China, and Singapore and is also imported from India for perfumery.

35. Peru Balsam: It is imported from Central America. The balsam exudes from the incisions made in the bark and trunk of the tree. The odour is smoky, agreeable and balsamic.

36. Pine apple, Bromelia Ananas: The fruits have well known narcotic odour.

37. Reseda odorata: This herbaceous plant of Northern Africa has a refreshing odour.

38. Rhodium: This climbing plant is indigenous to the Canary Islands. The root wood contains an essential oil.

39. Rosemary: This European plant contains an aromatic oil in leaves and flowers.

40. Santal wood: The tree is indigenous to the Eastern Asia. The wood resembles sandal wood. The white and yellow variety contains a very pleasant oil.

41. Sassafras: The bark of the root of this American tree has a very characteristic odour. It is also sold as saw dust. Safrol is the principal

constituent of the oil.

42. Spikenard, Nardostachys Jatamansi: This plant grows wild on the mountains in the East Indies. All the parts of the plant are aromatic, but the root consisting of fine fibres is very much used.

43. Star-Anise, Illicium: The fruits of this Chinese tree have seeds with sweetish taste and an odour resembling that of anise.

44. Storax: This balsamic product is derived from the tree, Liquidambar orientalis, and gives an agreeable odour on burning.

45. Sumbul root: It is indigenous to Turkistan. The light brown root covered with thin fibres has a penetrating odour of musk.

46. Sweet almonds: Sweet and bitter fruits of the almond tree both yield odourless oil, but the bitter almonds, on account of the decomposition of amygdalin, yield an oil of characteristic odour.

47. Sweet-flag root: Radix Calami: The roots of this creeping plant possess strong odour.

48. Thyme: This is a well known aromatic plant growing on calcareous soil. Thymus vulgaris yields an aromatic oil.

49. Tolu balsam: The balsam is derived from a tree indigenous to the northern portion of South

America, the incisions for which are made in bark. When warmed or sprinkled in powder form on glowing fire, it diffuses a very pleasant odour.

50. Tonka beans: The beans of this South American tree, Dipteryx odorata, contain the pleasant odour due to the presence of coumarin.

51. Vanilla: It is indigenous to tropical America and is a "king among aromatic plants." The fresh fruits possess the agreeable smell. The old vanilla has a fainter odour.

52. Vetiver, Andropogon muricatus: Vetiver is the fibrous root stock of a grass indigenous to India where fragrant mats are woven from it. The odour of the root somewhat resembles that of santal wood.

53. Ylang-ylang: The oil of this name is obtained from a plant, Uona odoratissima, of Philippines. It has got a remarkable fragrance.

APPENDIX III

HEATS OF COMBUSTION

The following table gives heats of combustion in small calories per gram of the substances burnt to carbon dioxide and water.

Substance	Calories	Substance	Calories
Air dried wood	4290-4050	Rice	3760
Resinous wood	5080	Barley	3300
Cane Sugar	3945	Wheat	3400
Lactose	3948	Mūng	3760
Maltose	3949	Urd	3760
Cellobiose	3944	Chanā	4000
Polysaccharides	4200	Arhar	3730
Cocoanut	6070	Molten butter	9300
Camphor	8677	Formaldehyde	4467
Methane	13270	Paraformaldehyde	4067
Paraffins	10965	Acetaldehyde	6323
Cresols	8170	Phenolic compounds	7000-8000

APPENDIX IV

Fumigants and Seasonal Variations

India has three seasons in proper, summer, rains, and winter. The two harvests are after winter in March, and after rains in the beginning of winter in October, or November. According to the seasonal condition, fumigants may be varied roughly as follows :

October to February—This is the best season for the 'fumigating mixture' described. The atmosphere is cool, calm and healthy.

March to May—This is the period when mosquitoes are troublesome. New grain, as barley, wheat, and peas, which gives out copious smoke and resinous substances as Guggul, Nāgarmothā, and Bālchhar may be used in plenty.

May to July—This is the period of intense summer. Ordinarily, the atmosphere is free from pathogenic bacteria. The fumigation of substances like Sandal wood, Agar, Tagar, Deodār and Sugandhbālā would diffuse out pleasant aroma.

July to October—This is the period of rains, insects and lice and the fumigating mixture is difficult to preserve for long. The constituents should be kept separately, and mixed while offering. Sugar, cloves, Taj, Tejpāt and kulanjan are suitable for this season.

APPENDIX V

For Vernacular and Sanskrit letters, the accentuated sounds are as follows:—

a	(अ)	as u in	*sun.*	(Guttural short)
ā	(आ)	as a in	*far.*	(Guttural long)
i	(इ)	as i in	*pin.*	(Palatal short)
ī	(ई)	as ee in	*seem.*	(Palatal long)
u	(उ)	as u in	*put.*	(Labial short)
ū	(ऊ)	as oo in	*moon.*	(Labial long)
e	(ए)	as ai in	*main.*	(Gutturo-palatal)
ai	(ऐ)			
o	(ओ)	as o in	*pole.*	(Gutturo-labial)

ṛ (ऋ), an obsolete vowel, resembling ri. (Lingual)

k, kh, g, and gh (क्, ख्, ग्, घ्) are guttural un-aspirated and aspirated consonants (k and g as in *king*).

ch, chh, and j (च्, छ्, ज्) are palatal un-aspirated and aspirated consonants (ch as in *chair* and j as in *jar*).

ṭ, ṭh, ḍ, ḍh, and ṇ (ट्, ठ्, ड्, ढ्, ण्) are hard lingual

un-aspirated and aspirated consonants (as t in *pot*, d in *dog*).

t, th, d, dh, and n (त्, थ्, द्, ध्, न्) are soft dental un-aspirated and aspirated consonants (th as in *thin*, d as th in *this*).

p, ph, b, bh, and m (प्, फ्, ब्, भ्, म्) are labial un-aspirated and aspirated consonants.

ś (श्) is palatal hard as sh in *ship*.
ṣ (ष्) is lingual hard (obsolete).
s (स्) is dental soft as s in *sun*.
ḥ (:, विसर्ग) is unvoiced aspiration.
ñ (ञ्) is the palatal *nasal*.

INDEX

D

O

P

R